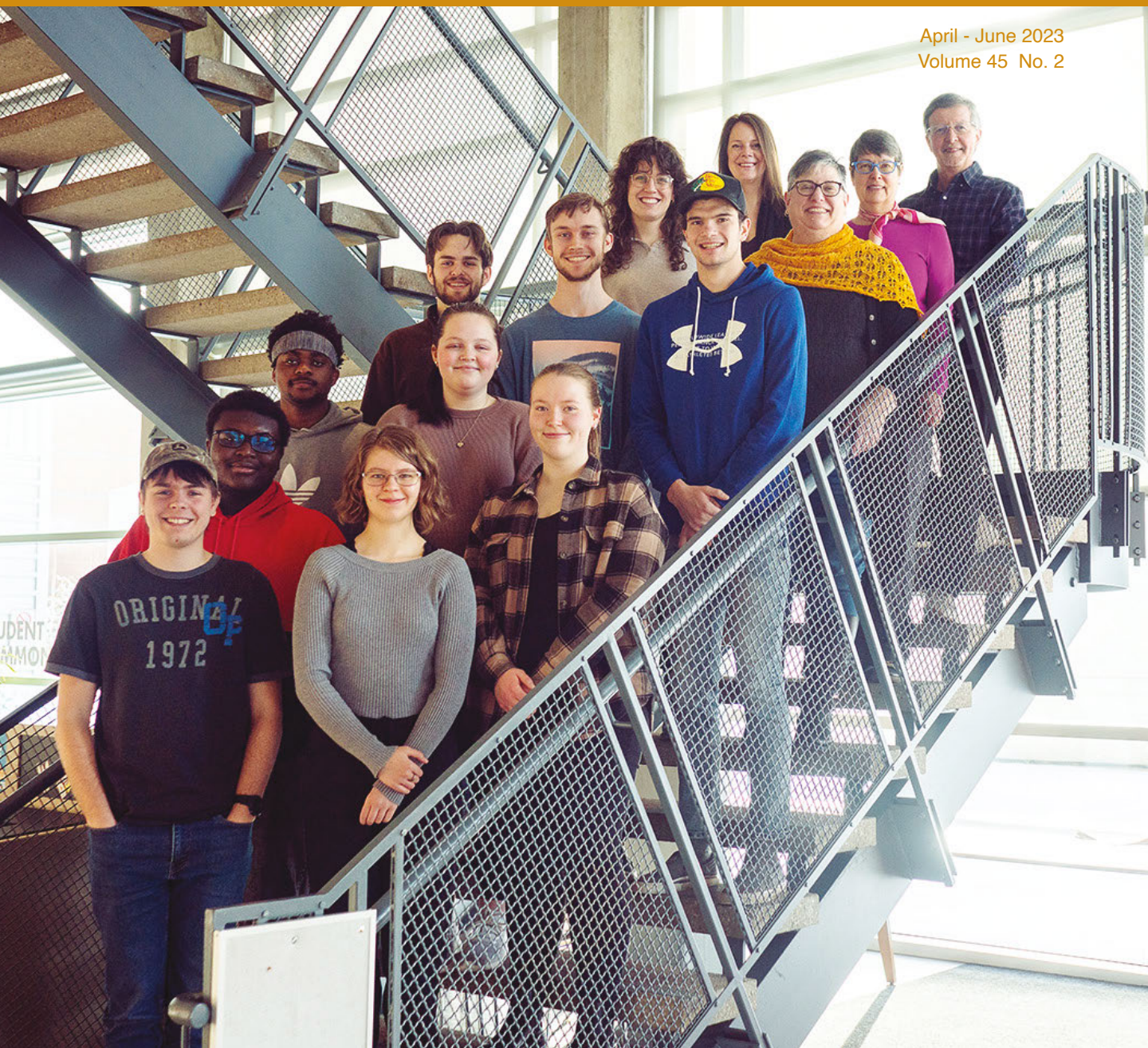


CHEMISTRY

International

The News Magazine of IUPAC

April - June 2023
Volume 45 No. 2



INTERNATIONAL UNION OF
PURE AND APPLIED CHEMISTRY

Ethics of Chemistry ►

Global Conversation on Sustainability ►



Chemistry International

CHEMISTRY International

The News Magazine of the
International Union of Pure and
Applied Chemistry (IUPAC)

All information regarding notes for contributors,
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available online at www.degruyter.com/ci

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Chemistry International (ISSN 0193-6484) is published 4 times annually in January, April, July, and October by De Gruyter, Inc., 121 High St., 3rd Floor, Boston, MA 02110 on behalf of IUPAC. See <https://iupac.org/what-we-do/journals/chemistry-international/> or <https://www.degruyter.com/ci> for more information.

ISSN 0193-6484, eISSN 1365-2192



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Cover: How to explore ethical questions in a chemistry seminar? Guided by Peter Mahaffy, a group of 3rd and 4th year chemistry undergraduate students of the King's University in Edmonton, Alberta, Canada, reviewed a book the titled "Ethics of chemistry" and share with CI their experience. See page [XX](#)



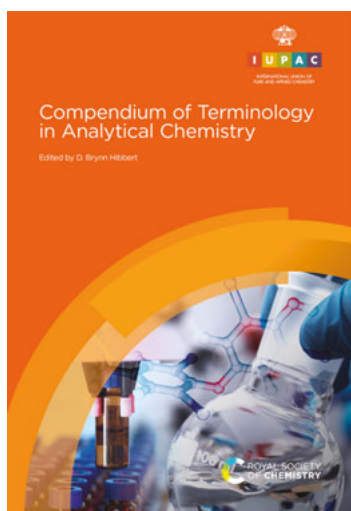
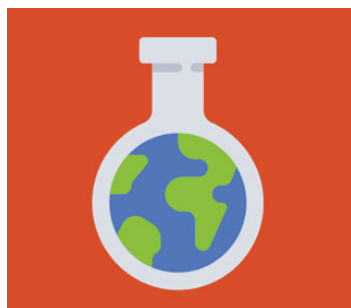
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Connecting Chemical Worlds

by Floris Rutjes

Chair of the Local Organizing Committee IUPAC|CHAINS 2023

It will still take a few more months before I can officially welcome you to IUPAC|CHAINS 2023, but since the preparations are already in full swing, it feels like we are getting close to the event. Behind the scenes we work hard to receive you all in the World Forum in The Hague from 20-25 August this year. We feel honoured that the Royal Netherlands Chemical Society (KNCV) was given the opportunity to host this year's IUPAC World Chemistry

Congress. To create a better national exposure, we joined forces with the Dutch Research Council (NWO), host of the annual CHAINS chemistry congress in the Netherlands, to ensure that we can turn this event into a great success!

Young Researchers

Hereby, I would like to invite especially the young researchers to come to IUPAC|CHAINS 2023! We have fantastic scientists giving the plenary lectures, like Chad Mirkin, Nicola Spaldin, Jennifer Thomson and Bartosz Grzybowski. Besides these established chemists, we aim to give a large podium to young scientists in particular. Thus, this congress will be a unique opportunity for PhD-students and postdocs to present their work for an international audience, meet their colleagues, discuss new chemistry, and perhaps jump-start their careers.

To make the congress even more suited for young chemists, a programme has been created that not

Line-up plenary speakers IUPAC|CHAINS 2023

The Scientific Programme Committee of IUPAC|CHAINS 2023 is very proud and honoured to announce the international speaker line-up. No less than nine plenary speakers will be present at IUPAC|CHAINS 2023, 20-25 August 2023 in The Hague, Netherlands.

On Sunday 20 August **Molly Stevens** (Imperial College London) kicks off with a lecture about how to detect diseases earlier through new materials. She will present advances in Raman spectroscopy for high-throughput label-free characterization of single nanoparticles that allow to integrally analyse a broad range of bio-nanomaterials.

Surface chemistry and catalysis expert **Mark Koper** (Leiden University) and molecular and cell biology expert **Jennifer Thomson** (Capetown University) will give their plenary presentation on Monday 21 August.

Koper's research focuses on fundamental aspects of electrocatalysis, theoretical and computational electrochemistry, and electrochemical surface science, in relation to renewable energy and chemistry.

Thomson's research field is the development of genetically modified maize resistant to the African endemic maize streak virus and tolerant to drought.

On Tuesday 22 August, it's time for professor of Inorganic Chemistry **Charlotte Williams** (Oxford University) and **Bartosz Grzybowski** (UNIST, South

Korea). Williams leads a research group investigating polymerization catalysis and polymer chemistry with a particular focus on improving polymer sustainability. Grzybowski has pioneered applications of artificial intelligence and network theory to synthetic chemistry. He will take us into the world of synthesis, processes, and reaction discovery in the age of computers.

On Wednesday 23 August, **Nicola Spaldin** (ETH Zürich) talks about developments in Materials Chemistry that are essential for addressing many of the world's most urgent problems, and presents one of her favourite emerging material classes, the multi-ferroics, which could help facilitate the transition to a new energy-efficient, climate friendly age.

Hiroaki Suga (University of Tokyo) gives his lecture on de novo discovery of pseud-natural peptides and products on Thursday 24 August. The second speaker on Thursday will be announced soon.

Chad Mirkin (Northwestern University) completes the list of inspiring speakers on the final day, Friday 25 August. Mirkin uses nanotechnology to discover and develop new materials and structures that make a difference in people's lives.

More information about the speakers can be found on iupac2023.org/plenary-speakers/ or follow IUPAC|CHAINS 2023 on LinkedIn, Twitter and/or Instagram via @iupac2023 to stay up to date about the conference, plenary speakers and other news.

only focusses on science, but also addresses other aspects of a scientific career. The International and the European Young Chemists' Networks (IYCN and EYCN), and Jong-KNCV have put quite some effort in composing a broader array of topics, the Young Programme, which I think will be really attractive for the younger generations of chemists.

Sustainability

During the congress, there will be a major focus on sustainability. Chemistry is a central science that can and has to significantly contribute to making our society more sustainable, which we wish to highlight during IUPACICHAiNS 2023. Creating a more sustainable world and contributing to address the Sustainable Development Goals concerns virtually all branches of chemistry, requiring new concepts and creative ideas.

We will bring the different chemistry fields together and jointly discuss the scientific challenges underlying the societal challenges. The interaction between science and society is a complex discussion anyway, in which facts and feelings both play a role. Being researchers, we should keep emphasizing that is important to use science as a basis for making policy decisions, scientific facts must weigh heavier than opinions. I think this could lead to lively discussions.

Sightseeing

Besides the chemistry, you should also see a bit of The Netherlands. During the congress, we will organize

several excursions to chemistry-related organizations and innovations in the Netherlands. For instance, it will be possible to visit the Headquarters of the Organization for the Prohibition of Chemical Weapons (OPCW), which is right next to the World Forum, but also the brand new Chemistry and Technology Centre of OPCW that is located elsewhere near The Hague.

I can also recommend you taking a stroll along the beach of Scheveningen, or visit the Mauritshuis—a museum next to the office of the Dutch Prime-Minister, displaying famous paintings of Rembrandt and Vermeer, like *The Girl with a Pearl Earring*—or *Panorama Mesdag*, a unique circular painting that makes you think you are on the beach. Or join the pubquiz or the Tuesday evening party to connect with your international colleagues in an informal setting.

Connecting Chemical Worlds

In conclusion, I hope to meet you soon on IUPACICHAiNS 2023 to experience a congress with inspiring chemistry and ample opportunities to meet with old or new friends. Personally, I really look forward to meeting researchers who I don't know yet and hope to be surprised by new eye-opening insights. I am convinced that international meetings like this are excellent opportunities to expand your horizon, engage with the diversity and inventiveness of chemistry and connect with new people and fields. To me that is what it is all about in the end: connecting chemical worlds. 🏆

Register now

From 20 to 25 August 2023, we would like to invite you to join us in the beautiful city The Hague in the Netherlands for IUPACICHAiNS 2023. The conference, themed '**Connecting Chemical Worlds**', brings together all disciplines of chemistry and is attended by a diverse international audience of chemists from both academia and industry. It is now possible to register. Register before 1 June 2023 and benefit from the early bird rate. Please visit <https://iupac2023.org/> for more information.

IUPACICHAiNS 2023 consists of several parts, namely the IUPAC General Assembly (18-25 August 2023) and the IUPAC World Chemistry Congress combined with CHAINS, the largest chemistry conference from the Netherlands (20-25 August 2023). In addition to plenary and invited lectures, IUPACICHAiNS will include parallel sessions with oral presentations,

focus sessions and poster presentations by junior and senior researchers. The full programme can be found on the website. We look forward to meeting you and your fellow chemists from around the globe!

Tag and win: who do you want to meet during IUPACICHAiNS 2023?

In August 2023, chemists from all over the world will come together in The Hague during IUPACICHAiNS 2023. The place to be to meet that one fellow chemist you've always wanted to talk to, but never got around to.

Who do you want to meet during IUPACICHAiNS 2023? Follow IUPACICHAiNS 2023 on LinkedIn, Twitter and/or Instagram, tag that specific person and win a great prize!

IUPAC's Role in UN Panel on Chemicals, Waste, and Pollution Prevention

by Javier García Martínez

The United Nations Environment Assembly (UNEA), in its Resolution 5/8, decided on the creation of the Intergovernmental Panel on Chemicals, Waste, and Pollution Prevention (IPCP) [1]. This resolution stated that a science-policy panel should be established to contribute further to the sound management of chemicals and waste, prevent pollution, and to convene—subject to the availability of resources—an ad hoc Open-Ended Working Group (OEWG). The OEWG started its work in 2022, with the ambition of completing it by the end of 2024 [2]. The next steps for this OEWG include the establishment of the panel, the selection of panel members, and the development of the assessment process. The panel members will be selected based on their expertise in the field of chemical pollution and their ability to provide a balanced and objective assessment of the state of chemical pollution. The assessment process will include a comprehensive review of the scientific literature, as well as input from stakeholders.

IUPAC should play a significant role in any international effort aimed at sustainable management of chemicals, reduction of waste production, and pollution prevention. For decades, the Union has been working and producing invaluable data, standards, and methods in different areas that are of interest for IPCP. It's worth highlighting the many contributions of the Chemistry and the Environment Division (Div VI), the Chemistry and Human Health Division (Div VII), CHEMRAWN, and the Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD) in promoting a more sustainable chemistry. The recommendations,

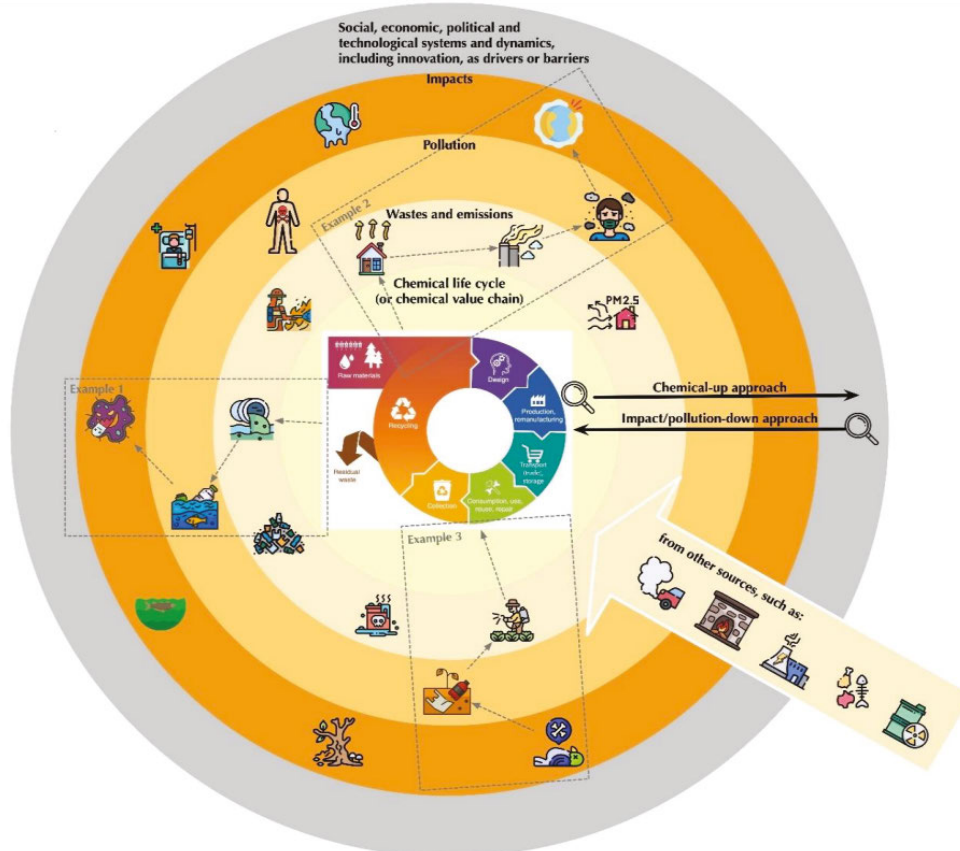
standards, and verified data provided by IUPAC and its different bodies are an essential part of any international effort aiming at reducing waste and pollution. In this regard, IUPAC efforts regarding minimizing production and dealing with e-waste shall be mentioned [3]. This includes an international conference held in Nigeria in November 2021 under the title of "CHEMRAWN XXII E-Waste in Africa" [4] and more recently a call for papers for a special issue of *Chemistry Teacher International* concerning the theme: "Effective teaching tools and methods to learn about e-waste" [5]. Other examples of how IUPAC can contribute to the goals of IPCP are its Technical Report on Human Exposure to Outdoor Air Pollution, its Glossary for Chemists of Terms Used in Toxicology, and the many conferences organized or supported in areas such as green chemistry, analytical chemistry, and chemistry education.

The IPCP operates through a network of experts from around the world who are appointed by the UNEP Governing Council. These experts work together to assess the state of knowledge on various chemicals and waste-related issues and to provide recommendations for action. The IPCP also works closely with other international organizations, such as the World Health Organization (WHO) and the United Nations Industrial Development Organization (UNIDO), to ensure that its advice is consistent with the latest scientific and technical knowledge.

In addition to its global assessments, the IPCP also provides technical assistance and capacity building to countries and organizations to help them implement chemicals and waste-related policies and programmes. This assistance can include providing training and resources on specific issues, such as the safe management of hazardous waste, or supporting the development of national chemicals and waste management plans.



Introduction slide of the webinar organized by the UN Environmental Programme to define the objectives and strategies of the Science-Policy Panel for chemicals, waste, and pollution prevention held online on 24 January 2023.



LEGEND

Wastes and emissions:



Pollution:



Impacts:



A schematic illustration of the linkages between chemicals, waste and emissions, pollution, and impacts within the social, economic, political, and technological systems. The icons within each circle are examples and not exhaustive. Source: The chemical life cycle/value chain is reproduced from European Parliament, "Circular economy: the importance of re-using products and materials", 3 July 2015. (reproduced from https://wedocs.unep.org/bitstream/handle/20.500.11822/41426/scope_science_policy_panel.pdf)

An important meeting towards the creation of the IPCP and selection of its members was held in Bangkok, Thailand, from 30 January to 3 February 2023. Several IUPAC representatives attended online and had the opportunity to contribute with ideas and proposals [6].

Prior to these activities, and convened by the Royal Society of Chemistry (RSC), several stakeholders gathered in a series of both online and in-person meetings to debate and agree on specific actions toward the creation

of IPCP. As a result of these activities, the Burlington Consensus was established, which provides a framework for the development of chemicals and waste-related policies and programmes, and is intended to guide the work of governments, industry, and other stakeholders. The Burlington Consensus also includes a number of recommendations that governments, industry and other stakeholders can take to promote the sustainable use of chemicals and the reduction of pollution and waste [7].



Second in-person meeting of the OEWG1.2 on Science-Policy Panel to contribute further to the sound management of chemicals and waste and to prevent pollution held in Bangkok, Thailand, from 30 January - 3 February 2023.

As the UN Secretary-General, Antonio Guterres, once said “There is no other way to deal with global challenges than with global responses” [8]. IUPAC will continue to play a crucial role in building solutions based on the best knowledge available and cooperation to fulfill our mission of fostering sustainable development, providing a common language for chemistry, and advocating the free exchange of scientific information. 🏆

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1. UNEA Resolution 5/8 entitled “Science-policy panel to contribute further to the sound management of chemicals and waste and to prevent pollution” <https://wedocs.unep.org/bitstream/handle/20.500.11822/40653/UNEP.SPP-CWP.OEWG.1%28I%29.INF.1.pdf>
2. Science-Policy Panel to contribute further to the sound management of chemicals and waste and to prevent pollution <https://www.unep.org/oewg1.2-ssp-chemicals-waste-pollution>
3. IUPAC Efforts in e-waste, E-waste: A Global Threat. <https://iupac.org/e-waste/>
4. CHEMRAWN XXII e-waste in Africa & the 44th Annual International Conference (AIC) of the Chemical Society of Nigeria (CSN), Global Electrical and Electronic Waste: Health Hazards For Africa <https://iupac.org/event/chemrawn-xxii-e-waste-in-africa/>
5. Special issue of Chemistry Teacher International concerning the theme: “Effective teaching tools and methods to learn about e-waste” <https://iupac.org/best-practices-in-chemistry-education-and-around-e-waste/>
6. Countries Begin Work Towards Science-Policy Panel on Chemicals <https://sdg.iisd.org/news/countries-begin-work-towards-science-policy-panel-on-chemicals/>
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Ethics of Chemistry: From Poison Gas to Climate Engineering

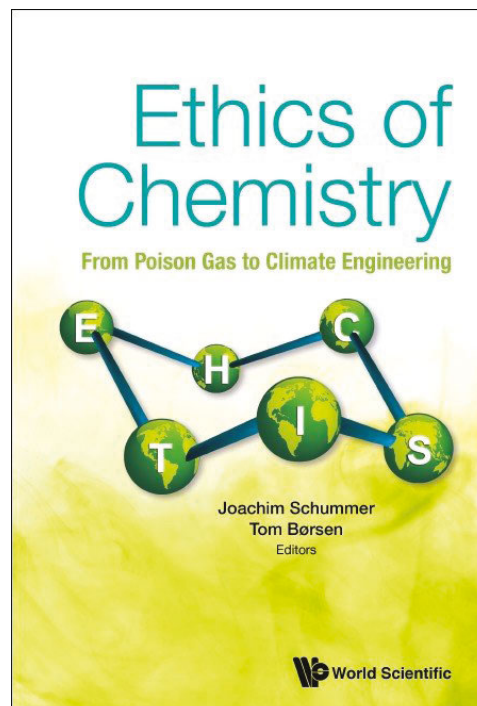
Joachim Schummer and Tom Børsen, editors
World Scientific Publishing, 2021, 559 pages
(<https://doi.org/10.1142/12189>)

reviewed by: Peter Mahaffy, Leah Martin-Visscher, and Cassidy VanderSchee (Professors at The King's University, Edmonton, Alberta, Canada), Cindy Slupsky and Heather Starke (Laboratory Instructors), and Jonathan Barwegen, Rio Bouwers, Jared Faulkner, Audrey Jenkinson, Tristan Loewen, Jadeyn Lunn, Ikenna Onyeagolu, Erin Pederson, and Sydney Visser (Chemistry Senior Seminar Students)

Imagine yourself a chemist confronted with the use of chemical weapons during World War IO. Or a citizen living in Bhopal, India, perhaps having negotiated the siting of the plant in your city as a politician or an employee bringing home a good wage working at Union Carbide's methyl isocyanate plant. Or perhaps you are a student in 2023 needing to make informed choices about climate engineering or the rapid full-scale extraction of rare-earth materials to mitigate the climate crisis. What is the right thing to do in each of these scenarios? How can the study of the moral values, norms, judgments, and virtues relevant to chemistry equip students to deeply reflect about the practice of chemistry and guide them to make informed and responsible choices about their behaviour as professionals?

Ethics of Chemistry, edited by Joachim Schummer and Tom Børsen, is a helpful collection of ethical case studies written by a diverse group of authors. This compilation is meant to introduce and help university chemistry students wrestle with questions of ethics, and provides resources to help fill a significant gap in the education of many scientists who don't receive formal training in ethics in their chemistry courses and programs.

Rather than simply providing *Chemistry International* readers with the thoughts of faculty who have read the collection, we thought it would be helpful to describe the experiences of a group of 3rd and 4th year chemistry undergraduate students as we piloted various chapters of this book in a weekly one-hour seminar course in the Fall (September – December 2022) academic term at the King's University, a small undergraduate university in Edmonton, Alberta, Canada. We describe the topics we worked on together, some approaches we took in



using active-learning strategies to introduce this material to students, and summarize some of the student's thoughts about what they found helpful about the book and their suggestions for what could be improved.

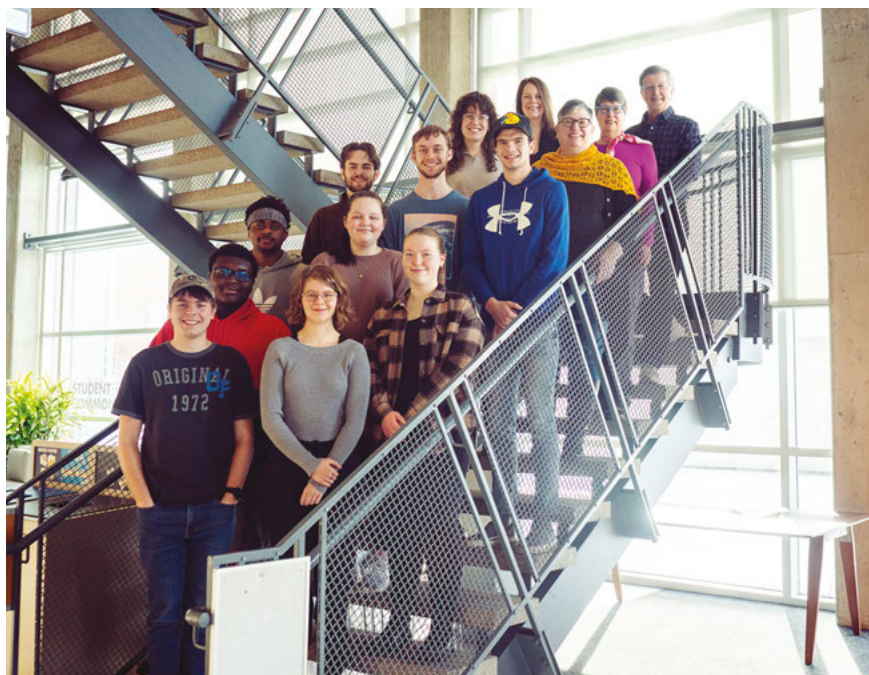
After an introduction to the topic, the book helpfully categorizes the 19 chapters into five large parts that collectively give a rich and comprehensive overview of ethical issues of relevance to chemists:

- I. Misuse and Misconduct;
- II. Unforeseen Local Consequences;
- III. Global and Long-Term Influences and Challenges;
- IV. Challenging Human Culture; and
- V. Codes and Regulations.

Our seminar group worked through the chapters described below:

Introduction: Students and faculty had a group discussion of the purpose of this new book and identified other places in the curriculum at our liberal arts institution where ethics is already introduced. We discussed the potential value for students who were nearing the end of their undergraduate education to dig more deeply into some additional ethical case studies. Students wrestled with the author's distinction between ethics **in** chemistry and ethics **of** chemistry, and discussed how the book's approach provided a complementary fit with students' previous introductions to philosophical ethics in other courses they had taken as part of our university general education requirement.

Ethics of Chemistry: From Poison Gas to Climate Engineering



King's University students and faculty who used Chemistry of Ethics in a senior undergraduate seminar.

From bottom left: Jared Faulkner, Audrey Jenkinson, and Erin Pederson (behind Audrey). Behind Jared is Josh Olisa and behind him Ikenna Onyeagolu, and to Ikenna's right is Sydney Visser. Then from left to right are Tristan Loewen, Rio Bouwers, and Jonathan Barwegen; Standing on the second row from the top from left to right are Cassidy VanderSchee and Heather Starke. In the very back are Leah Martin-Visscher, Cindy Slupsky, and Peter Mahaffy.

Chapter 3: Ethics of Chemical Weapons Research: Poison Gas in World War One (From Part I on Misuse and Misconduct). Students were asked to imagine themselves as chemists during WWI and to think about the ethical struggles and questions they might be grappling with as they became aware of, or perhaps even asked to participate in, the development of chemical substances designed to kill military or civilian populations. They then worked in small groups to frame an ethical response to this story from either the perspective of utilitarianism or deontological ethics, terms defined in the Introductory chapter.

Student Reflections on Chapter 3 (poison gas). Students applauded the communication of different “excuses” (using the author’s term) to validate chemical weapons research, but they felt that it put forward a somewhat stark and uncompromising stance about the ethics behind them. Students would have liked to see more consideration of the various pressures that chemists felt during that time and the consequences that they would face if they turned away from chemical research. They pointed to modern day examples where the choices to participate in such work are sometimes mandated by the military of national scientists and it would be very difficult for a scientist to say no. They would have also liked to see more elaboration of the environmental impacts that were created with the use and disposal of chemical weapons during and after the war and the long term effects on wildlife and surrounding populations.

Chapter 5: Corporate and Governmental Responsibilities for Preventing Chemical Disasters: Lessons from Bhopal (from Part II: Unforeseen Local Consequences) After reading the ethical analysis of the 1984 Bhopal industrial disaster at the Union Carbide isocyanate plant in central India, students came to the seminar having written down their thoughts on what went wrong, who was at fault, what ethical rules were violated, and how future disasters could be prevented.

Student Reflections on Chapter 5 (Bhopal). Students described this case study as an insightful reflection of ethical indignities within chemistry, and a lesson to prevent future chemical disasters. They felt the authors demonstrated the consequences of corporate and political greed as well as neglect of chemical safety and lack of moral responsibility. They appreciated the comprehensive presentation of the potential causes of the disaster, highlighting the multiple failings of the plant. Students commented on the value of analyzing this case study using philosophical principles of ethics such as the golden rule and the precautionary principle, offering insight to the potential moral development within chemistry, and relevance to present industrial issues. Some felt that such strong attribution of corporate greed oversimplified the situation, where local decision makers welcomed the major economic boost the plant brought to their community. It was interesting and important for students to speculate on why this plant was sited in India and whether

differential environmental regulations played a role in that decision. The reputational damage to the company and chemical industry in general was evident because of bad ethical decisions. Through additional research activities, students explored how this widely publicized industrial disaster led to important global initiatives by industry to take responsibility, including the introduction of the Responsible Care and other programs.

Chapter 12: The Ethics of Rare Earth Elements (REE) Over Time and Space (from Part III: Global and Long-Term Influences and Challenges). To create greater engagement from each member of the class, the instructors divided the students into two groups and assigned each to take one side of a debate on the proposition: *“Be it resolved that, in light of the climate crisis, society should move as quickly as possible to extract rare earth elements to support energy transitions.”* Using the chapter as a starting point, and doing additional research, each side was asked to frame their position on the debate with consideration of ethical issues related to both intergenerational and environmental justice. Students found the debate format to be particularly lively and engaging. Following the debate, the class took the discussion further by reflecting on the ethical tensions created by needing to consider the REE needs of both present and future generations, while living within our planetary boundaries for climate change. Students considered the urgency of the climate crisis and the requirements for REE for rapid transitions from fossil fuel combustion to electrification of energy supply. They also did further research to explore the scarcity of REE and debated how large-scale exploitation of REE now might leave future generations without ongoing supplies, but how failure to extensively use REE now may leave future generations at or beyond a climate tipping point. They noted that REE resources are concentrated in only a few countries at present, and that rapid extraction of those resources creates ethical issues related to equitable access and can create unsafe and unfair working conditions for those who extract them for use in other countries.

Student Reflections on Chapter 12 (REE): Students found this chapter to be solid, readable, and interesting, providing a comprehensive evaluation of REE technology and the ethics of this practice as it is today. They valued the insights that came from applying lenses of environmental and intergenerational justice to the ethical questions about REE use and commented that these aren't the only ethical lenses that could be

applied. One student summed up the way we covered this topic this way: *“The debate format was a great way to discuss this chapter. It was very enjoyable to take part in, and provided far greater motivation to actually dig into the chapter compared to our standard format. Also, as we talked about today, a chapter on ethics really does lend itself to the idea of a debate.”*

Overall Student Reflections on Using Ethics of Chemistry. Students journaled after each of the sections described above and also reflected at the end of the academic term on what they had learned, what they found helpful, and areas that might have been stronger or more balanced in the provision of resources. Overall, their experience was positive in using resources to help them explore more deeply ethical case studies, and to focus their attention on a more formal application of the relevant ethical issues. They appreciated the historical narratives, diversity of expertise, voices, and perspectives of the author teams for each chapter. The complexity of choices facing the players in each story was appreciated and they commented on the integrity with which this complexity was usually presented. As seen in their reflections about each of the chapters above, they also offered several examples of where they felt the ethical issues were presented with too much generality and perhaps a bit of oversimplification.

The instructor team felt that the fact that the constructive and substantive critique by students of the approach and of the individual case studies, in itself is a positive reflection on the way the book equipped them to apply ethical considerations to complex cases in chemistry. We recommend this resource to other instructors in separate ethics courses and in similar seminar courses to the one we offer. It is perhaps most suited to upper-level students, but with appropriate scaffolding would also make a helpful introduction to ethics to beginning chemistry students. By using a case study approach, where chemistry, historical context and questions of ethics are woven together, this book provides numerous, accessible starting points for chemistry instructors who wish to enrich the content and context of their lectures and courses. We were pleased to note that the relatively high price of the print book, which would significantly limit its accessibility, is mitigated by the offering of a reasonably priced e-book. 📖

Submitted for the co-authors by Peter Mahaffy, member of IUPAC's Standing Committee on Ethics, Diversity, Equity, and Inclusion. Email: peter.mahaffy@kingsu.ca; <https://orcid.org/0000-0002-0650-7414>

An IYCN/IUPAC Joint Effort to Creating a Sustainable Future Worldwide

by Juliana L. Vidal and João Borges

Since 25 September 2022, the International Younger Chemists Network (IYCN) and the International Union of Pure and Applied Chemistry (IUPAC) are jointly organizing the Global Conversation on Sustainability (GCS, <https://www.gcs-day.org>) in an annual fashion. This day has been chosen because it marks the anniversary of the United Nations Sustainable Development Goals (UN SDGs) [1].

The IYCN/IUPAC joint GCS project, which is supported by the IUPAC Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD), aims to coordinate a yearly one-day event worldwide focusing on sustainability towards a common good by providing guidelines on different possible formats to organize and register events by the community, as disclosed on the GCS website. Moreover, the GCS project is sponsored by Merck KGaA, Darmstadt, Germany, and is supported by several organizations, including the International Year of Basic Sciences for Sustainable Development (IYBSSD2022), Beyond Benign, the International Sustainable Chemistry Collaborative Centre (ISC3), the Global Young Academy (GYA), and the Chemicals and Waste Platform of the Major Group for Children and Youth of the United Nations Environment Programme (UNEP-MGCY).

In the first year of the GCS project, which coincided with the beginning of the IYBSSD2022 aiming to celebrate the key role of basic sciences for sustainable development, more than 30 events were organized around the world, both in-person and online (<https://www.gcs-day.org/events>). We have reached out to some of the event organizers and asked them to share their individual experiences, why they have decided to jump in and become involved in the organization of a GCS event, and how the event has impacted their lives, as highlighted below. We hope such feedback and diversity of opinions and thoughts would encourage and actively engage colleagues from around the world to get involved with the GCS, come up with their own events in the next edition (25 September 2023) and join us in this global effort in accelerating the pace



Figure 1. Social media promotion of the GCS Day 2022 coordinated by the IYCN and IUPAC. The #Sustain4All was used to track and promote the communication and engagement between the community and organizers of the GCS events happening worldwide.

towards a sustainable future for the benefit of Society and our Planet.

Goals, Coordination, and Implementation

The objectives of the GCS project (iupac.org/project/2021-034-2-041/) are aligned with the goals of both the IYCN and IUPAC to tackle the UN SDGs of the UN 2030 Agenda for Sustainable Development by raising awareness and encouraging conversations among diverse stakeholders, including university scientists, governmental and non-governmental organizations, business entities, and the whole scientific community on implementing sustainable solutions globally. The project seeds upon previous collaborative projects and activities by the IYCN and IUPAC targeting the UN SDGs [2]. Such ambitious goal is expected to be accomplished globally, on a yearly and sustainable basis, through (i) the *implementation* of sustainable actions, practices, and mindset among the chemistry community across the world, (ii) the *communication* of local activities that could be applied at national and international levels, (iii) *connecting and engaging* young and established scientists, as well as the general public in taking effective actions for the achievement of a sustainable future, and keeping track of their progress, and (iv) *launching synergies and collaborations* across different countries, cultures, and continents to further

implement the practices discussed (Figure 2).

The GCS project is chaired by João Borges (Immediate Past Chair and Advisor of the IYCN for 2022-2023) and Javier García Martínez (President of IUPAC for the biennium 2022-2023) and encompasses 13 Task Group members. The diversity is showcased in terms of gender and geographical location, being the team represented across 11 different countries, namely Portugal, Spain, Brazil, The Netherlands, Germany, Canada, Egypt, USA, Malaysia, Australia and Jordan (Figure 3).

GCS Day 2022 Across the World

In-person events for a sustainable future

Francesca Kerton (Memorial University of Newfoundland, Canada) is a member of the GCS Task Group and has been thoroughly involved in the creation and promotion of the project, and its further implementation at Memorial University. *Entitled Scientists and Sustainability*, the in-person event held at the Core Science Facility was able to promote sustainability in science and build confidence in young chemists through flash presentations followed by discussions regarding the need for collaborative work to achieve the UN SDGs.

According to Kerton, “both graduate and

undergraduate students volunteered to give short ‘elevator pitch’ style presentations on their research or a topic related to sustainability. I was very grateful for their participation and energy on the day. A big thank you in particular to Kavi Heerah (Ph.D. student, Reader lab) (Figure 4), as he was the first to step forward and encouraged others to take part. We had a small audience on the day (around 20 people) including some local high school chemistry teachers and we hope they took some of our passion for sustainability back to their classrooms. I was able to secure some funding from the Canadian Society for Chemistry local section for this event and this allowed me to buy refreshments (hot and cold drinks, cookies and cakes). After presentations were complete, we chatted informally with a cup of coffee in hand to reflect on the UN SDGs and other sustainability issues.”

Regarding the future of the GCS, Francesca is looking forward to further dissemination and application of the project. In this context, she already has plans for the event at the Memorial University in 2023: “I am excited for GCS Day becoming an annual event and I hope more people will take part in activities around the world this year. As Chair of the IUPAC Chemical Research Applied to World Needs (CHEMRAWN)

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Figure 2. A summary of the goals, objectives, and expected outcomes of the GCS. The project is based on the implementation, communication, promotion, and collaboration between individuals and organizations in contributing to achieve the UN SDGs and promoting sustainable development globally.

The Global Conversation on Sustainability



Figure 3. Task group members of the IYCN/IUPAC joint GCS project encompassing members of the IYCN, IUPAC and other entities, and their countries of origin.

Committee, we are planning a webinar featuring chemical education focused on the topic of e-waste for GCS Day in 2023 and I will be busy encouraging other Canadian Universities to host in-person events. Closer to home, one of my own Ph.D. students, Sachel Christian-Robinson, will be leading the organization of a local event at Memorial University of Newfoundland this September."

Local discussions during the GCS Day 2022 were also performed at McGill University (Montréal, Canada) and at the British University in Egypt. The motivation behind the planning of 'McGill's GCS' came from the necessity of promoting a sustainable change. Julio Terra and Jasmine Hong are both graduate students at McGill University and highlighted that "there is a need for more sustainable conversations in our department." According to Terra and Hong, panelists from different backgrounds (*e.g.*, academia, government, research, industry, and education) participated in an engaged discussion during the event to promote sustainable actions: "We even started the discussion of implementing a nitrile glove recycling program in the department." At the British University in Egypt, Hassan Nageh was behind the organization of a round-table discussion on

sustainability held at the Nanotechnology Research Centre, in which "external researchers and staff members were invited to discuss the role of science and nanotechnology in the implementation of the UN SDGs towards a greater impact on our world."

In South America, one of the GCS in-person events was organized by Cintia Milagre (State University of São Paulo, UNESP, Brazil). Milagre and the Institute of Chemistry (IQ) at UNESP celebrated not only the GCS Day 2022, but the whole week during the *#GlobalGoalsWeek: Contributions of Synthetic Organic Chemistry to Drug Development and Production Innovations for Sustainable Development*. About 50 attendees of the event at UNESP had the chance to participate in an important discussion with a Merck representative and hear from industry, as well as academia the importance of "implementing Green Chemistry actions from the beginning of the experimental work and not as an optimization strategy."

Cintia became involved with the GCS Day 2022 because she believes that "forming the next generation is essential if we seek fundamental changes. The GCS Day was a fantastic opportunity to spread Green and Sustainable Chemistry among undergraduate and

The Global Conversation on Sustainability

graduate students.” According to Cintia, the event “was fuel to continue going on. Being surrounded by young chemists, the future of Chemistry—thirsty for knowledge about Green and Sustainable Chemistry and how to use chemistry to reach the UN SDGs —see the spark in their eyes and use the opportunity to share experiences with them and the experts from the university and industry is priceless.” Milagre also made a call for action as a participant or organizer of the GCS Day to “everyone interested in sustainability and sharing experiences about what actions are within our reach. As an organizer, I would say that investing our precious time in such an activity is quite rewarding, personally and professionally, especially when you have all the necessary institutional support and encouragement.”

Virtual events for a sustainable future

Besides in-person discussions about sustainability, the GCS Day 2022 also took place online in live or even via pre-recorded formats. One example of the latter consists in the video *Research for Sustainability* (<https://youtu.be/sRclYbfhyKE>) created by the Italian IUPAC Young Observers (Figure 5). Using their own GCS format, the group discussed, in an informative video, the main challenges involving the achievement of a sustainable future and potential solutions developed by chemists worldwide. Elisa Carignani, postdoctoral researcher at the National Research Council of Italy

and member of the Italian IUPAC Young Observers group, said that the creation of a pre-recorded video for the GCS Day 2022 was “an opportunity to develop communication skills for a non-specialized audience and get some experience in video-making.” According to Carignani, the leadership skills acquired during group planning and coordination of the GCS event was “another important part of the work,” and she believes that those will be very useful in her career. Carignani also suggests others “invest time in participating/organizing a GCS event. It is an occasion to gain a broader perspective, and a source of inspiration to find renewed enthusiasm to bring in your professional life.”

The Brazilian Chemical Society (SBQ) has also joined the GCS Day 2022 through the webinar *Education and Scientific Dissemination for the SDGs of the 2030 Agenda*, which was recorded and can be found online (<https://www.youtube.com/live/ziCqR-9peblk>). During this GCS event, attendees were able to understand the importance and relevance of taking actions aimed at promoting the 2030 Agenda within the context of education for sustainable development. According to Romeu C. Rocha-Filho from the Federal University of São Carlos (UFSCar, Brazil), the motivation for this event came from the fact “that SBQ has an ongoing action focused on sustainability” that promotes the discussion of ways that chemistry can contribute to Brazil’s achievement of a sustainable future.



JOIN US TO LEARN
ABOUT KAVI'S RESEARCH
3.00-5.00 PM, SEPT 25
CSF 1302, MEMORIAL UNIVERSITY

‘MY RESEARCH AIMS TO BETTER UNDERSTAND HOW IRON AND DISSOLVED ORGANIC CARBON FROM THE PEATLANDS AND BOREAL REGIONS OF NL INTERACT WITH EACH OTHER AND HOW THEY ARE TRANSPORTED TO THE COASTAL ENVIRONMENT. THIS WORK WILL HELP BETTER INFORM CLIMATE MODELS ON THE EXPORT OF CARBON AND IRON AND HELP FILL KNOWLEDGE GAPS ON THE BIOGEOCHEMICAL CYCLES OF CARBON AND IRON’



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Thank you to the NL Section of the CIC for
sponsoring refreshments

Figure 4. Kavi Heerah’s presentation at the GCS Day 2022 at Memorial University of Newfoundland and flyer used both in social media and internally for the promotion of the ‘Scientists and Sustainability’ event.



Figure 5. Snapshots of the *Research for Sustainability* video created by the Italian IUPAC Young Observers, highlighting the different scientific approaches used by researchers in the group for addressing the UN SDGs.

“Learning, spreading, and applying Green Chemistry” was the motivation behind the joint organization of the *Let's Talk Sustainability: A Global Conversation* event by the Asociación de Licenciados en Ciencias Químicas del Paraguay (ALQUIMPY), Asociación de Biotecnólogos del Paraguay and Colegio de Biólogos del Paraguay at the Faculty of Exact and Natural Sciences of the National University of Asunción (FACEN-UNA). With over 40 participants, the online event consisted of a set of diverse lectures with the aim to increase sustainability in chemistry, include more Green Chemistry topics in the academic curriculum, and further promote a culture of sustainability. In addition, a new network was born, and the Green Chemistry Paraguayan Network was created through the organization of this GCS event (Figure 6).

Lourdes Gisella Duarte Pereira was behind the organization of the GCS Day 2022 at FACEN-UNA and highlights the importance of the network created as a support for the communication and implementation of sustainable actions: “As a result of GCS 2022, an important network of professionals was obtained who are interested in working in the line of sustainability, be it in social, academic, and research work. We have managed to raise awareness about our environment and how important it is to have a sustainable culture to

improve our quality of life in the present and future. The GCS is a great opportunity to make networks and work to change our vision of what sustainability is, exchange ideas, and have the help of people who are working in that.”

Another online event was organized by the Task Group of the IYCN/IUPAC Joint GCS Project. During the *Sustainability for a Bright Future: A Global Conversation for Achieving the SDGs*, participants from all over the world had the chance to hear from, address questions, and be inspired by Javier García Martínez (President of IUPAC), Amy Cannon (Co-Founder and Executive Director at Beyond Benign), Anna Becker (Specialist Policy and Communications at the International Sustainable Chemistry Collaborative Centre — ISC3), and Jeffrey Whitford (Head of Sustainability, Social Business Innovation and Life Science Branding at MilliporeSigma) on initiatives, activities and actions towards pursuing sustainable solutions for a sustainable future globally.

The speakers not only discussed the urgent need for addressing the UN SDGs by 2030, but also highlighted the fundamental importance of education, taking effective actions, and thinking sustainably at the molecular level for a systemic change. In this context, the role of Green Chemistry was thoroughly discussed

The Global Conversation on Sustainability



Figure 6. Promotional material and screenshots of the GCS Day 2022 at the Faculty of Exact and Natural Sciences of University of Asuncion (FACEN-UNA) in Paraguay. One of the main outcomes of the *Let's Talk Sustainability: A Global Conversation* event was the creation of the Green Chemistry Paraguayan Network.

as a fundamental piece towards the path of sustainable development. Javier García Martínez showed the work of IUPAC in targeting and tackling the UN SDGs, as well as different opportunities for young scientists to be connected and engaged. Amy Cannon talked about Beyond Benign, which works in preparing our future workforce to think sustainably through the insertion of Green Chemistry in the chemistry curriculum. Anna Becker talked about the different initiatives by ISC3 in enabling the transformation towards sustainable chemistry, including the 2nd Global Sustainable Chemistry Week, happening in 2023. Jeffrey Whitford displayed the initiatives of Merck KGaA, Darmstadt, Germany and, in particular MilliporeSigma (the life science business of Merck KGaA, Darmstadt, Germany, operating in the US and Canada) on sustainability, including the DOZN 2.0, a tool for measuring how “greener” a process actually is. These metrics are essential in the field of Green Chemistry and in the development of more sustainable processes and products. The talks were followed by a panel discussion, in which Green Chemistry resources were shared, and the role of young researchers for addressing the UN SDGs was amplified (<https://youtu.be/ByGDCiBY9aQ>).

The Zimbabwe Chemical Society was also present in the GCS Day 2022 and Kudakwashe Chingono, a

postgraduate researcher at the University of Leeds, helped in the coordination of the *Early Conversations for Sustainable Action in Zimbabwe*. The hybrid event took place online and in Harare, Gweru and consisted of a series of lectures and panel discussions with the goals to initiate the dialogue, open room for collaboration and mentorship, and promote sustainable actions in Zimbabwe. Kudakwashe believes that, as a young researcher, “the exposure to sustainable research through practice and experiences of other researchers at different career stages is important.” He highlights how the involvement in the GCS helped him to learn from others and share information: “Prior to the GCS, I had never encountered organizations such as Beyond Benign which have a uniquely useful approach to sustainable science. I enjoyed learning about their tools, and the opportunities available. In a developing country context, where I’m from, this means we can do research differently, educate about sustainability from the grassroots. I envision being part of and nurturing a generation of science that is conscious about the future.”

What the Future Holds

According to the feedback obtained by the event organizers from across the world during the GCS

Day 2022, the first year of the GCS project was able to support an initial dialogue and even provide local outcomes regarding the implementation of sustainable actions for a sustainable future. As the need for global conversations contemplating and correlating sustainable development, transforming science education, tackling societal, economic and environmental challenges, societal inequities, Green and Sustainable Chemistry research, and public policies continues to increase, we hope that the number of events organized by individuals, institutions, and organizations from all over the world in the upcoming GCS Day (September 25th, 2023) follows the same trend for the benefit of everyone. The very first year of the GCS project was only the beginning of a universal call for action and engagement of everyone upon addressing the UN SDGs at different levels and, therefore, we expect to see many other GCS events, in as many countries as possible, and in several formats in the years to come in jointly contributing to this global effort of achieving a sustainable future globally. Regardless of the magnitude of consequences achieved, “every sustainable action begins with a conversation” and the GCS Task Group is proud to promote both the implementation of a culture of sustainable practices in the community and effective actions, as well as the active communication and collaboration of our society to achieve a sustainable future. To learn more about the GCS project, find out the events that happened last year, and be inspired to plan and organize your own event for the year ahead, have a look into the guidelines at the GCS website (<https://www.gcs-day.org/guidelines>) and follow the **#Sustain4All** on Twitter (https://twitter.com/GCS_Day) and LinkedIn (<https://www.linkedin.com/company/gcs-day/>). If you want to ask questions, engage with or support the GCS project, please do not hesitate to contact us at contact@gcs-day.org.

We very much look forward to seeing your event for the GCS Day 2023 registered at the GCS website and joining us in this global conversation towards a sustainable future worldwide! We count on all of you!

Acknowledgments

We would like to thank all event organizers for their participation in the GCS Day 2022. Moreover, we would like to thank Francesca Kerton (Memorial University of Newfoundland, Canada), Jasmine Hong and Julio Terra (McGill University, Canada), Hassan Nageh (The British University in Egypt, Egypt), Cintia Milagre (State University of São Paulo, Brazil), Elisa Carignani (Institute for the Chemistry of OrganoMetallic Compounds – ICCOM, Italian National Research

Council – CNR – ICCOM-CNR, Italy), Romeu C. Rocha-Filho (Federal University of São Carlos, Brazil), Lourdes Gisella Duarte Pereira (Faculty of Exact and Natural Sciences of the National University of Asunción, Paraguay), and Kudakwashe Chingono (University of Leeds, United Kingdom), for their kind feedback as per the organization of an event during the GCS Day 2022. We thank the International Year of Basic Sciences for Sustainable Development (IYBSSD2022), Beyond Benign, the International Sustainable Chemistry Collaborative Centre (ISCC), the Global Young Academy (GYA), and the Chemicals and Waste Platform of the Major Group for Children and Youth of the United Nations Environment Programme (UNEP-MGCM) for their support, as well as Merck KGaA, Darmstadt, Germany for its financial support to the IYCN/IUPAC joint GCS project. We also thank all Task Group members of the IYCN/IUPAC joint GCS project for their invaluable efforts, support, and contributions in the planning of the GCS project and GCS Day, and for making them a reality. 🙏

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3. Juliana Vidal (juliana_vidal@beyondbenign.org) is a Higher Education Program Manager at Beyond Benign. She received her Ph.D. from Memorial University of Newfoundland in 2021 and completed her postdoctoral research at McGill University in 2022 working with Green Chemistry. Juliana was selected a CAS Future Leader in 2020 and is currently a member of the Task Group of the IYCN/IUPAC Joint Project Global Conversation on Sustainability and a member of the Chemicals and Waste Platform of the Major Group for Children and Youth of the United Nations Environment Programme (UNEP-MGCM). <https://orcid.org/0000-0001-8755-7220>

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Alessandro Volta: Still Fully Charged After 200 Years

by S. Borsacchi, M. Guidotti, A. Sanson,
A. Minguzzi, A. Pozzi, A. M. Paci, F. Kerton,
M. Peruzzini

In the framework of the International Year of Basic Sciences for Sustainable Development (UNESCO IYBSSD July 2022–2023), the Italian IUPAC NAO organized an open and educational event titled Alessandro Volta's heritage and electrochemistry to respond to the great challenges of the future. Designed to highlight the role of chemistry as a fundamental science to respond to big challenges, the day event was organized in collaboration with two important scientific Italian institutions including the Italian National Research Council (CNR) and the University of Insubria, with the support of IUPAC and its Committee on CHEMical Research Applied to World Needs (CHEMRAWN) (IUPAC project #2022-018-1-021), and in collaboration with the International Science Council.

At the center of the event was the great and creative scientist Alessandro Volta and his extraordinary invention of the voltaic pile, which paved the way to electrochemistry and its applications. This great legacy had an extraordinary impact on innovation and scientific progress over the last two centuries and will, most likely, play an even more important role in the coming years in achieving and maintaining sustainable development.

The event was held on 24 October 2022, in Como,

the birthplace of Volta, a splendid Italian town lying on the charming lake of Como, famous for its natural and artistic beauties and for its villas and palaces, as well as a great example of a territory dedicated to innovation, internationalization, and sustainable growth. Furthermore, being close to the Swiss border, Como is ideally located at the crossroads between Mediterranean/Italian cultural area and the Northern European one, as a relevant meeting point between different cultures and traditions. It is worth noting that the University of Insubria, the local academic institution which hosted the event in the beautiful space of the Romanesque Basilica of Sant'Abbondio, is strongly committed to sustainability, environmental protection and ethics, having, since 2018, an UNESCO chair on Gender Equality and Women's Rights in the Multicultural Society.

Students from both the university and secondary schools, researchers and citizens were invited to participate, in person or virtually, through several communication channels, such as the IUPAC and Italian NAO websites, the mailing lists of the CNR and the Italian Chemical Society and social media. Some 70 people attended the meeting in person and 30 joined the event online.

The workshop was opened by two video messages from the presidents of IUPAC, Javier Garcia Martinez, and ISC, Peter Gluckman. In particular, the IUPAC President highlighted the importance of the IYBSSD as a great opportunity for all scientists to work together to



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Participants of the workshop in the Sant'Abbondio cloister (Como)



build a better future for all people. Electrochemistry is vital for achieving a sustainable development and in this respect Volta's role and the strong connection between past and future is particularly crucial. In the second video-message, Peter Gluckman, reflecting on Volta's discovery, underlined the importance of basic sciences and their strong impact on our lives and stressed the importance of collaborations between scientists and scientific unions in this critical period.

In keeping with both IUPAC and ISC Presidential messages and auspice, the synergy between the two organizations has been very positive and very effective for the Italian NAO to design and implement this event for the IYBSSD.

Supporting messages from the representatives of the sponsors of the event, the Lombardy section of the Italian Chemical Society (SCI), the Royal Society of Chemistry—Italy Section, the International Society of Electrochemistry and De Nora Foundation concluded this opening part.

Finally, Stefano Serra Capizzano, Prorector of the University of Insubria, pointed out the greatness of Volta as a scientist but also as a humanist, mentioning his commitment for the acquisition of Galileo's manuscripts in the Como Library. These remarks reminded and showed the importance of moving next generations researchers towards a unified knowledge as in the spirit of this celebration.

The event was split into two parts: the first saw the participation of three eminent speakers who gave three stimulating and complementary lectures in Italian, moving from the history of the life and discoveries of Alessandro Volta to the future of electrochemistry,

looking to batteries and clean energy.

Luigi Fabbrizzi, emeritus professor of the University of Pavia, where Volta was professor and rector, brought the audience back to the end of the 1700s and the beginning of the 1800s, telling in a lively and fascinating way the history of the life and the scientific career of Alessandro Volta, a multifaceted pioneer of experimental physics and chemistry. Indeed, Volta, observing animal phenomena and learning from other brilliant physicians and biologists, such as Luigi Galvani and Lazzaro Spallanzani, identified the phenomenon of electricity caused by the contact between two metals. He built the first battery, the so-called voltaic pile, which he actually named *artificial electric organ*. Volta was an extraordinary experimentalist, who tested most of his ideas on himself and on the environment around him. He travelled extensively abroad and communicated with many scientists across Europe. His merits were recognized, being awarded the Copley medal in 1794, but he also experienced difficulties and competitiveness in scientific publications, even at that time. Nicholson, inspired by Volta's studies, discovered the electrolysis of water, which directly leads us to one of the most important present and future paths of electrochemistry.

Moving from the past to the future, Catia Arbizzani, professor at the University of Bologna, gave an overarching lecture on batteries and their crucial role in the decarbonization. To electrify more and more our lives, we need efficient and sustainable batteries, capable of storing and accumulating energy. Even if, at present, the most widespread batteries are based on lithium ions, it is absolutely necessary that research moves toward more sustainable and efficient systems,



The organizers and the speakers of the event. From left to right: A. Minguzzi, M. Guidotti, F. Bella, A. Pozzi, A.M. Paci, M. Peruzzini, L. Fabbrizzi, C. Arbizzani, and S. Borsacchi.

improving materials and processes, with particular attention to recycling and reuse. The lecturer pointed at the importance of combining photovoltaics and batteries and exhorted all the young people present to a better and responsible use of energy and devices.

The last lecture was given by Federico Bella, professor at the Turin Polytechnic, who outlined an interesting picture of the synergies to be adopted to effectively approach the energy transition and decarbonization. The different tools and methods that chemistry can provide must complement, rather than compete, with each other. In this sense combining photovoltaics with electrolysis, making solar fuels, producing energy vectors, such as hydrogen or, better, ammonia via electrochemical reduction of nitrogen, are key topics on which multidisciplinary efforts must be devoted.

These last ideas introduced the second part of the event, a hybrid round table, in presence and online. This session, held in English and chaired by

Alessandra Sanson, acting director of CNR-ISSMC (Institute of Science, Technology and Sustainability for Ceramics), saw the participation of the three lecturers together with Francesca Kerton, Chair of IUPAC CHEMRAWN Committee and Lidia Armelao, President of the Inorganic Chemistry Division of IUPAC (Division II) and current Director of CNR-DSCTM (Department of Chemical Sciences and Materials Technology). The panellists discussed the role of chemistry, electrochemistry, and partnerships in building sustainable development. It clearly emerged the involvement of chemistry and the need for chemists to work towards the many different UN SDGs, from energy, to environment to zero hunger, as well as the importance of collaborating with other scientists to address the current challenges. In the specific fields of electrochemistry, the partnership with scientists, engineers, and industries is mandatory for optimizing both materials and processes, which are still the core of all electrochemical processes and are



Video messages of the IUPAC president, J. Garcia Martinez and of the ISC President, P. Gluckman.

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crucial for future advances. Reflecting on the future of electrochemistry, the panellists also highlighted the importance of focusing on recyclable and reusable devices, with a careful choice of non-critical chemical elements.

A common message, strongly raised by the speakers, concerned the need of setting up specific multidisciplinary university curricula aimed at training specialists in electrochemistry and batteries, who are and will be increasingly needed.

This event, full of history, concepts, ideas, and perspectives, clearly demonstrated the importance of chemistry for our present and future and their great potential for building a diffuse well-being for all. It has been a very instructive and inspiring moment for all participants, and in particular, for the younger ones. We hope that chemists and electrochemists will significantly contribute to build a better future.

The video recording of the event is available on the Italian NAO website (www.iupac.cnr.it).

Starting from this event, the three lecturers kindly agreed to prepare in the coming months a feature article to be submitted for publication on *Pure and Applied Chemistry*. 🏆

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Alessandro Volta: Man or Myth?

Biography prepared by Luigi Fabbrizzi

Alessandro Volta was born in Como on 18 February 1745 into a family of minor nobility, the sixth of seven children. The older brothers and sisters all devoted themselves to religious life (friars, priests, and nuns). Alessandro chose a different life: from the age of thirteen he attended the Jesuit school, then entered the seminary, but at eighteen he left to devote himself to the study of physics, in particular electricity. As an autodidact, Volta began doing experiments at home and corresponding with important Italian and foreign physicists. At the age of twenty he began to frequent the laboratory of his friend Giulio Cesare Gattoni, a canon and amateur physicist. At the age of twenty-four Volta published his first work on electricity (*"De vi attractiva ignis electric ac phaenomenis inde pendentibus"*), a treatise that he sent to the most illustrious Italian scientists. In 1774, he was appointed Superintendent and Regent of the Royal Schools of Como. In 1775 he communicated to Joseph Priestley the invention of a surprising instrument, which he called the "perpetual electrophorus." This apparatus was able to produce electricity not by friction, as in the electrostatic machines of that time, but by induction and was immediately applied to the systematic production of abundant and lasting supply of electricity in all European laboratories. Volta so achieved considerable notoriety in the scientific world: in 1775 he was appointed professor of Physics at the 'Real Ginnasio'

in Como and in 1778 he was called to the University of Pavia, where the chair of physics, formerly held by Carlo Barletti, a piarist father, was split into that of Experimental Physics—with a pronounced phenomenological character—which was assigned to Volta, and that of General Physics—based on solid mathematical foundations—which remained with Barletti. In contrast to the provincialism of the Italian scientists of the time, who travelled very little, thus avoiding comparison with other cultures, Volta between 1781 and 1782 travelled in Europe through Savoy, Switzerland, Germany, Belgium, Holland, France and England, with the aim of finding new instrumentation for his laboratory and to exchange ideas and build relationships with the leading scientists of the time.

In Pavia Volta continued his research in the field of electrostatics inventing new devices such as the condenser electrometer and perfecting known apparatuses. The turning point was 1791, when Luigi Galvani, professor of anatomy and obstetrics at the University of Bologna, published a pamphlet in Latin entitled *"De viribus electricitatis in motu musculari,"* which he sent to leading Italian scientists, including Volta. Galvani had observed that when an arc made of two different metals is touched to a muscle and a nerve of a treated frog (i.e. killed and skinned), the legs of the frog contract as in the grip of toxic convulsions. Galvani formulated the idea that there exists an animal electricity, an

Alessandro Volta: Still Fully Charged After 200 Years

electric fluid secreted by the brain which, conducted by the nerves, reaches and activates the muscles. Volta repeated Galvani's experiments and extended them to a variety of animals (mammals, reptiles, birds, insects, worms) each time observing contraction induced by contact with a dimetallic arc and formulated a new theory on the electrical nature of the phenomenon: electricity is generated by the contact of two different metals (metallic electricity) and the muscular or nervous tissue of the frog behaves as a 2nd species conductor (today we say electrolyte). The frog (or the animal in question) closes the circuit. Volta published these results in the periodical of the Royal Society of London, *Philosophical Transactions*, the most prestigious scientific journal of the time (A. Volta, *Account of Some Discoveries Made by Mr. Galvani of Bologna, With Experiments and Observations on Them*. *Phil. Trans. R. Soc. Lond.* 1793, 83, 10-44, in French). The article aroused great interest and Volta was awarded the Copley Medal (the equivalent of the Nobel Prize at the time) by the Royal Society for this. A scientific controversy on the nature of electricity, whether animal or metallic, then arose between Galvani and Volta, a controversy that was also bitter, but always conducted within the limits of mutual respect and esteem. Volta settled the matter in 1800 when he published the work: A. Volta, *On the Electricity Excited by the Mere Contact of Conducting Substances of Different Kinds*, *Phil. Trans. R. Soc. London* 1800, 90, 403-431, in French). The article described a device consisting of a column of contiguous pairs of silver and zinc discs, interfaced by cardboard discs soaked in salt water (a device later defined as pile in English literature). For the design of the pile Volta was inspired by the columnar and discoidal structure of the electric organs of the torpedo raia (electric fish already known in Roman times) Volta's pile generated an electric shock in anyone who touched the two ends with their hands and the shock was revealed the stronger the greater was the number of pairs of metal discs of which it was made. During the months of construction of the pile, in the midst of the war between Austria and Napoleon, the University of Pavia had been closed by the Austrians and the professors fired (some, like Father Barletti, imprisoned for "democracy and Jacobinism"). Volta built the pile in his country house in Lazzate (Como) and this explains why he limited himself to experimenting the effects of the electric current on his sense organs and not on the variety of animals that his biologist colleagues at the



Alessandro Volta (1745 – 1827)

University of Pavia from Institute directed by Lazzaro Spallanzani had treated and made available in 1793. Volta's article was a resounding success and hundreds of professional or amateur scientists throughout Europe built piles, tried to improve their efficiency and explored their applications.

Volta returned to his university, reopened by the victorious Napoleon and was invited by Napoleon himself to Paris to illustrate his research in front of the Académie des Sciences. Napoleon rewarded Volta with a medal, the title of Senator of the Kingdom of Italy and the title of Count (with attached generous salaries). Volta gradually reduced his didactic and scientific activities in Pavia, partly due to family commitments (he had married at the age of fifty, had three children and wanted to take care of their education), partly because he was satisfied with the enormous success and perhaps aware of not being able to compete in the development of the pile with much more aggressive European research centers, operating in countries with a more consolidated and widespread scientific and technological tradition than Italy in the 19th century. In 1819 he retired from the University, in 1827 he died in Como at the age of 82.



Keith R. Solomon Recognized with the IUPAC International Award for Advances in Harmonized Approaches to Crop Protection Chemistry

On 6 February 2023, the IUPAC Division of Chemistry and the Environment, Advisory Committee on Crop Protection Chemistry announced that the 2023 IUPAC International Award for Advances in Harmonized Approaches to Crop Protection Chemistry will be presented to Keith R. Solomon, School of Environmental Sciences, University of Guelph in Guelph, Canada.

Solomon is recognized for his creative and internationally influential force for science-based and harmonized approaches to crop protection chemistry. Solomon's contributions are rooted in his role as a leading investigator and scholar concerning chemical behavior and significance in the environment. His well-known research, much of which has been focused on risk assessment of important crop protection chemicals, has been leveraged to advance harmonized approaches to chemical assessment through expert collaborations as well as educational and global outreach efforts. Solomon's longstanding contributions to the science of crop protection chemistry have helped firmly establish harmonized approaches for the science of risk assessment as a critical underpinning for management of crop protection chemistry.

See details at <https://iupac.org/keith-r-solomon-recognized-with-the-iupac-international-award-for-advances-in-harmonized-approaches-to-crop-protection-chemistry/>

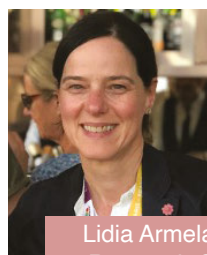
Awardees of the IUPAC 2023 Distinguished Women In Chemistry or Chemical Engineering

To celebrate International Day of Women and Girls in Science this 11 February IUPAC announced the awardees of the IUPAC 2023 Distinguished Women in Chemistry or Chemical Engineering:

- Lidia Armelao, National Research Council and University of Padova, Italy
- Annette G. Beck-Sickinger, Leipzig University, Germany
- Chunying Chen, National Center for Nanoscience and Technology of China, Beijing, China
- Bin Liu, National University of Singapore, Singapore
- Laura McConnell, Bayer U.S., Crop Science Division, USA
- Marcia Foster Mesko, Federal University of Pelotas, Brazil
- Jyotirmayee Mohanty, Bhabha Atomic Research Centre, Mumbai, India
- Tatjana Parac-Vogt, Katholieke Universiteit Leuven, Belgium
- Gill Reid, University of Southampton, UK
- Mikiko Sodeoka, RIKEN, Japan
- Nguyễn Thị Kim Thanh, University College London, UK
- Marinda Wu, Dow (retired), USA

The awards program, initiated as part of the 2011 International Year of Chemistry celebrations, was created to acknowledge and promote the work of women chemists/chemical engineers worldwide. Each year since 2011, the award has gained more attention in the global community. These 12 awardees have been selected based on excellence in basic or applied research, distinguished accomplishments in teaching or education, or demonstrated leadership or managerial excellence in the chemical sciences. The Awards Committee has been particularly interested in nominees with a history of leadership and/or community service during their careers. The awards presentation will be made during the IUPAC World Chemistry Congress to be held in August 2023.

Mary Garson, Chair of the IUPAC Committee for Ethics, Diversity, Equity and Inclusion, comments: "I warmly congratulate this year's group of 12 awardees, selected from an impressive list of high achieving and creative women chemists or chemical engineers from all around the globe. In their individual stories, each of



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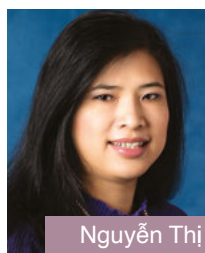
Marcia Foster Mesko,
Federal University of
Pelotas, Brazil



Jyotirmayee Mohanty,
Bhabha Atomic Research
Centre, Mumbai, India



Gill Reid,
University of
Southampton, UK



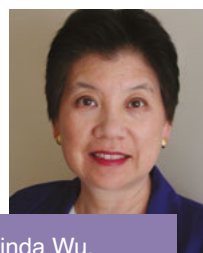
Nguyễn Thị Kim Thanh,
University College
London, UK



Tatjana Parac-Vogt,
Katholieke Universiteit
Leuven, Belgium



Mikiko Sodeoka,
RIKEN, Japan



Marinda Wu,
Dow (retired), USA

the 2023 nominees reveal a willingness to share their expertise and experiences with other chemists, and a passion for science. Their activities and outreach advance the chemical and chemical engineering sciences in so many diverse ways. As we acknowledge all of the nominees and congratulate the 12 awardees, I am confident that their individual stories will inspire women scientists worldwide and provide encouragement to all of us to advance the chemistry of the future.”

The International Day of Women and Girls in Science is a global day celebrating achievement and

promoting full and equal access to and participation in science for women and girls. The day marks a call to action for further achieve gender equality and the empowerment of women and girls. The year 2023 is also the International Year of Basic Science for Sustainable Development. IUPAC celebrated both of these global initiatives with a Global networking Breakfast event (www.iupac.org/gwb/) held on February 14 and with the theme of “Breaking Barriers in Science”.

<https://iupac.org/iupac-2023-distinguished-women/>

Green Chemistry for Life



PHOSAGRO / UNESCO / IUPAC Partnership In Green Chemistry for Life

Green chemistry has become a focus for cutting-edge research into sustainable technologies. These technologies may reduce or even eliminate the production and use of hazardous substances in mining and in the design, manufacture and application of chemical products, and may also lead to energy savings, a better environment and improved human health.

Research in green chemistry and associated areas in biochemistry, geochemistry, biotechnology, ecology and healthcare give young scientists ample opportunity to demonstrate their inventiveness and provide important input to sustainable development. With this in mind, the Green Chemistry for Life project was launched in 2013 by UNESCO's International Basic Sciences Programme (IBSP) and PhosAgro, the largest producer of phosphate-based fertilizer in Europe, in close cooperation with IUPAC.

Objectives

PhosAgro/UNESCO/IUPAC research grants in green chemistry programme offers research grants of up to USD \$30,000 each to scientists aged 39 or under, for innovative research projects that respect the 12 principles of green chemistry, to assist them in implementing their work.

In addition to seeking to harness the talents of young scientists and the fruits of their research for the advancement of green chemistry. The programme sets out to raise awareness among decision- and policy-makers, industrialists and the public at large of the great opportunities green chemistry offers in contributing to address the multitude of pressing societal needs.

Call for Applications

Young scientists are invited to submit their applications for PhosAgro/UNESCO/IUPAC research grants in green chemistry. The 8th call for applications is open until 30 June 2023.

See all details unesco.org/en/basic-sciences/green-chemistry

2023 World Metrology Day—20 May

The OIML and the BIPM are pleased to announce that the Resource Website is now live: <https://www.worldmetrologyday.org/>

The theme in 2023 is “Measurements supporting the global food system.” This theme was chosen because of the increasing challenges of climate change, and global distribution of food in a world whose population reached 8 billion at the end of 2022.

The 2023 poster was designed in association with Sistema Interamericano de Metrología (SIM) and the Instituto Nacional de Tecnología Industrial (INTI), Argentina.

World Metrology Day

Measurements supporting the global food system

20 May 2023
www.worldmetrologyday.org

Bureau International des Poids et Mesures (BIPM) and OIML logos are also present.

On the Resource Website, you may download the Press Release, the Directors' Message, and the poster in English and in French. The poster may be downloaded in PDF and PhotoShop formats.

Last year's World Metrology Day was a huge success; we hope to build on that success in 2023. Please help to spread the word about World Metrology Day and let the World Metrology Day Team know by email worldmetrologyday@oiml.org about the events you are organising in your country so that we can include them on the website. For inspiration, you can see the type of events organised by other NMIs in previous years on the website.

<https://www.worldmetrologyday.org/>

Call for International Reviewers

The National Research Foundation of Ukraine (NRFU) is seeking to expand its pool of international reviewers for their proposals, which are in all areas of fundamental research (including humanities). Currently, they have only 1,000 foreign reviewers and at least need to double them.

Interested scientists are invited to register with NRFU as reviewers. See details at <https://nrfu.org.ua/en/about-us/expert-procedures/>

In Memoriam

IUPAC is saddened to learn the recent passing of the following members and fellows:

- **Vadim T. Ivanov** (Russia) passed 8 April 2022 – Organic and Biomolecular Chemistry Division
- **Dusan Berek** (Slovakia) passed 28 June 2022 – Polymer Division
- **Michael Schwenk** (Germany) passed 7 July 2022 – Chemistry and Human Health Division, Emeritus Fellow
- **Norman E. Holden** (USA) passed 18 Aug 2022 – Inorganic Chemistry Division
- **Warren H. Powell** (USA) passed 19 Sep 2022 – Chemical Nomenclature and Structure Representation Division, Emeritus Fellow
- **Chin-Han (Melissa) Chan** (Malaysia) passed 19 Dec 2022 – Polymer Division, Committee on Chemistry Education
- **John D. Bradley** (South Africa) passed 23 December 2022 – Committee on Chemistry Education
- **Ian M. Mills** (UK) passed 24 Dec 2022 – Physical and Biophysical Chemistry Division, Interdivisional Committee on Terminology, Nomenclature and Symbols, Emeritus Fellow
- **Yusuf Yagci** (Turkey) passed 30 Jan 2022 – Polymer Division

What is digital IUPAC? Tools for an increasingly digital research culture



Ms. Leah McEwen
Cornell University



Dr. Fatima Mustafa
Texas A&M San Antonio



Dr. Ian Bruno
Cambridge Crystallographic Data Centre



JOIN US ON: May 31 @ 12:00 pm (EST)
REGISTER TODAY: <https://bit.ly/WorldFAIR>



Mechanisms of chemical vapor generation by aqueous boranes for trace element analysis—A rather long and unfinished story

1. Introduction

In analytical chemistry, the term Vapor Generation (VG) encompasses a variety of derivatization techniques that play an important role in the determination and speciation of trace elements by means of atomic optical and mass spectrometry.

Chemical vapor generation (CVG) was the first of these applied in the late 1960s, and in 1971 a decisive impulse to CVG arose from the introduction of NaBH₄ (THB) as a derivatization reagent. The tetrahydridoborate ion is able to convert many elements at trace concentrations, such as Ge, Sn, Pb, As, Sb, Bi, Se, Te, to their corresponding volatile hydrides, and mercury to Hg⁰. CVG by aqueous [BH₄][−] became very popular and found many applications to trace element determinations and speciation, including methods used by regulatory agencies. Much later, in the early 2000s, the scope of CVG by [BH₄][−] derivatization would extend to several transition metals.

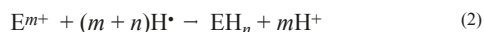
At the time of publication of the first monograph on CVG by Dědina and Tsalev, in 1995, it was evident that, after more than twenty years since its introduction, the analytical chemistry community had disregarded the fundamental aspects of CVG. Studies reporting method development and optimization were carried out empirically, and the field was dominated by erroneous concepts and controversial aspects.

Dedicated studies on fundamental aspects of CVG began around 2003 and stimulated the launch of an IUPAC 4-year-long project in 2007 which contributed to the clarification of erroneous concepts and controversial aspects. CVG mechanistic studies further continued after 2011. The IUPAC project also stimulated studies on fundamental aspects of other emerging vapor generation techniques, such as photochemical VG, in order to avoid the empirical approach that plagued CVG for many years.

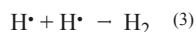
This article briefly illustrates the course of studies that have contributed to the understanding of some fundamental aspects of CVG, and the current state of knowledge.

2. Erroneous concepts in CVG

In 1979, Robbins and Caruso postulated the following mechanism for the CVG of volatile hydrides:



Where E is the analyte element (Ge, Sn, Pb, As, Sb, Bi, Se, Te, Hg, *etc.*). Even if not explicitly mentioned by the authors, it could be assumed that the molecular hydrogen, which is evolved by [BH₄][−] hydrolysis, is formed by recombination of hydrogen radicals:



This reaction pathway was later named the “nascent hydrogen mechanism,” because the active species generating the volatile hydrides were believed to be transient species of hydrogen (*i.e.* hydrogen radicals, H[•]), which were considered to be hydrogen in its nascent form. Reactions 1-3 reported the observed final products of CVG, *i.e.*, B(OH)₃, EH_n and H₂.

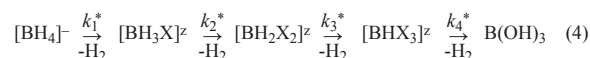
This mechanism contains some erroneous concepts: (i) the hydrolysis of THB is not a single step reaction and (ii) atomic hydrogen H cannot be formed by hydrolysis of THB. Despite no evidence supporting or refuting the theory, the nascent hydrogen mechanism was reported for many years, becoming very popular and accepted by a large part of the analytical community.

3. Clarification of controversial aspects and removal of erroneous concepts of CVG

3.1 Initial studies on hydrolysis of THB

Initial experiments, from 2003 to 2004, demonstrated that volatile hydrides can be generated by replacing THB with milder amine borane (AB) reagents (BH₃NR₃, R=H, alkyl). Further dedicated experiments demonstrated that hydrides can be generated by the direct action of AB on the analytical substrate without the need to generate any hydrogen (H[•] or H₂) by hydrolysis of the borane reagent (reactions 1, 2).

Soon after, attention was dedicated to the mechanism of hydrolysis of THB. Analytical chemists had unfortunately ignored the studies on the mechanisms of THB hydrolysis reported in the early seventies. Reaction (1) is largely incomplete, because it considers only the final products. In fact, as it was reported in the fundamental chemistry literature, it takes place stepwise:



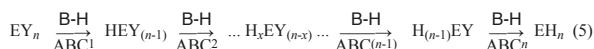
The hydrolysis of THB passes through hydrido-boron intermediates $[\text{BH}_{4-n}\text{X}_n]^z$ (where $\text{X} = \text{H}_2\text{O}$, OH , etc., $n = 1-3$, $z = 0, \pm 1$ is the charge; for $n = 0$ $[\text{BH}_{4-n}\text{X}_n]^z = [\text{BH}_4]^-$). Also, molecular hydrogen (*not* atomic hydrogen as for reaction 1) is formed stepwise with different kinetics. The degree of complexity of reaction 4 is better illustrated in a reaction scheme reported recently (Figure 1).

Dedicated studies—reported in 2004—were in agreement with reaction (4), particularly that $[\text{BH}_4]^-$ and hydrido-boron intermediates (B–H) are able to generate volatile hydrides by direct interaction with analytical substrates. Each of the B–H species of reaction 4 can be active in the generation of hydrides, as demonstrated by dedicated experiments.

3.2. Mechanism of hydrogen transfer in the generation of volatile hydrides

From 2005 to 2007, dedicated experiments using deuterium labelled reagents were carried out with the aim of clarifying the mechanism of hydrogen transfer in the generation of volatile hydrides from As^{III} , As^{V} , Sb^{III} , Bi^{III} , Ge^{IV} and Sn^{IV} substrates. The most informative results were achieved by using gravimetric mixtures of $[\text{BH}_4]^-$ and $[\text{BD}_4]^-$ in H_2O , and under ideal analytical conditions, *i.e.*, analyte at trace level, high borane/analyte molar ratios ($> 10^4$), absence of chemical additives and interfering species. They revealed that

the formation of volatile hydrides (i) takes place stepwise, by the direct transfer of hydrogen atoms from boron ($[\text{BH}_4]^-$ and/or B–H species) to the analyte atom of the substrate, and (ii) the hydrogen atoms incorporated into the final hydrides come from different borane molecules. These evidences led to the conclusion that, similar to the mechanism of hydrolysis, hydride formation also takes place stepwise:



Where EY_n is the analyte substrate ($\text{E} = \text{element}$, such as As , Sb , Bi etc, $\text{Y} = \text{ligand}$, such as OH , Cl etc), B–H is a hydridoboron species, ABC is the analyte-borane complex, and $\text{H}_x\text{EY}_{(n-x)}$ is a hydrido-metal(loid) complex (HMC, $1 \leq x \leq n-1$). The ABC complexes are intermediate compounds through which the hydrogen transfer takes place, and their existence was confirmed by MS. The hydrogen transfer leads to the formation of intermediate hydrido-metal(oid) complexes $\text{H}_x\text{EY}_{(n-x)}$ (HMC, $1 \leq x \leq n-1$).

The reaction scheme 5 was considered to also be valid for transition and noble metals. The only difference is represented by the stability of intermediates and final products, which can evolve to species different from those that are formed in CVG of classical hydrides.

It is interesting to note that some applications of CVG

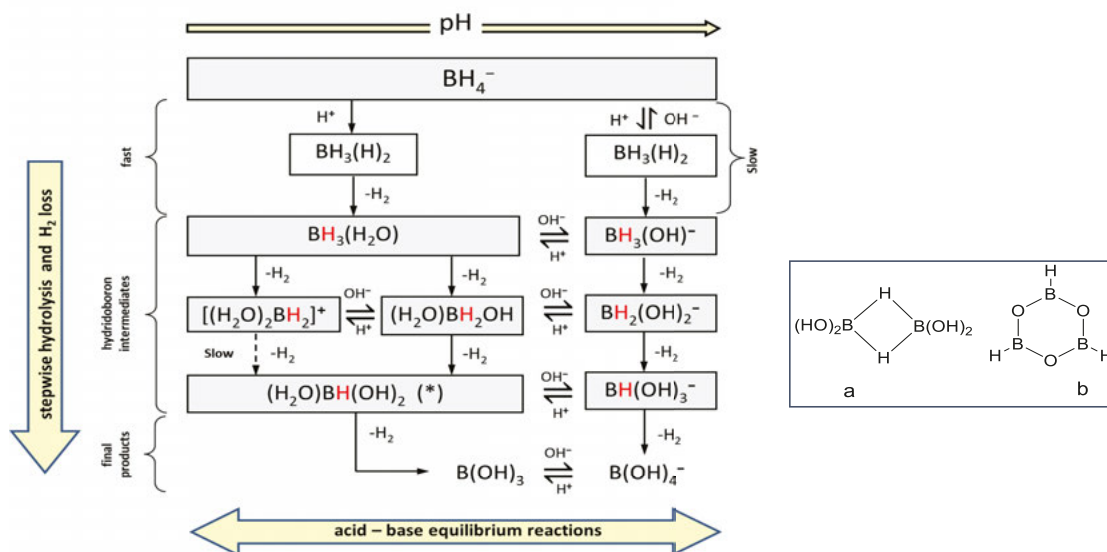


Figure 1. Qualitative representation of reaction pathways involved in the aqueous hydrolysis of THB. (*) a and b are conceivable structures of neutral monohydridoboron species. Reproduced from A. D'Ulivo, The contribution of chemical vapor generation coupled with atomic or mass spectrometry to the comprehension of the chemistry of aqueous boranes, J. Anal. At. Spectrom. 34 (2019) 823_827 [19], with permission of The Royal Society of Chemistry.

generation, performed much later from 2016 to 2018, confirmed that ABC intermediates are involved in the generation of methylated arsanes following the reaction of As-sugar with THB. Also, it was demonstrated that the extent of demethylation during methylarsane generation $[\text{Me}_n\text{AsO}(\text{OH})_{3-n} - \text{Me}_n\text{AsH}_{3-n} (n=1-3)]$ depends on the nature of the hydridoboron species (see reaction 4) and it increases in the order: $[\text{BHX}_3]^z$, $[\text{BH}_2\text{X}_2]^z$, $[\text{BH}_3\text{X}]^z$, BH_4^- .

3.3. The IUPAC project

The newly collected evidence seemed quite convincing and stimulated in 2007 the launch of an IUPAC project (#2007-041-1-500), which focused on the clarification of the fundamental mechanisms governing CVG of volatile hydrides by aqueous boranes. The completion of the project, in 2011, brought a suitable degree of rationalization to the mechanisms governing CVG, reconciled the collected evidence with that previously reported in the chemistry literature, and toadied in the removal of erroneous concepts.

Nevertheless, the analytical model (reactions 4, 5) cannot explain several observations such as the mechanism of action of some interferences and additives, as well as the formation of oligomers at high analyte concentrations. Therefore, after 2011, studies continued to better understand the processes controlling CVG. A summary of these studies is reported in Table 1. Among these, those which led to the definition of more general reaction models are illustrated in the next section 3.3.1.

3.3.1 More general reaction models. When the concentration of analyte increases and/or the borane/analyte ratio decreases (non-analytical conditions), the formation of hydride oligomers, nanoparticles and precipitates is observed. The analytical reaction model

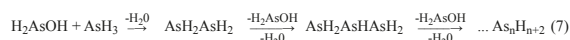
cannot explain this evidence.

Just to give an example, arsane formation can be schematized as follows:



Where $\text{AsH}(\text{OH})_2$, $\text{AsH}_2(\text{OH})$ are HMC intermediates.

Deuterium labelled experiments on arsanes in non-analytical conditions generate evidence supporting a reaction model wherein the hydrogen transfer competes with condensation reactions. A simplified reaction scheme is reported in Figure 2 for a generic HMC intermediate, $\text{RAs}(\text{OH})\text{H}$. Among the possible condensation reactions, those leading to formation of easily identifiable volatile polymeric arsanes represent evidence of HMCs intermediates. For example, for $\text{HMC}=\text{H}_2\text{AsOH}$ a condensation cascade reaction can be suggested:



Where di- and tri-arsane can be easily identified. Competition between hydrogen transfer and condensation reactions can also be confirmed for methylarsane formation. Increasing the analyte concentration up to the millimolar level led to formation of high molecular weight polyarsanes, nanoparticles and precipitates.

The condensation among HMC intermediates, final product and analytical substrate contribute to a redrawn a non-analytical reaction model, which is valid both in non-analytical and analytical conditions.

The non-analytical reaction model can be employed to also explain some types of interferences. It introduces a different view of the mechanisms of interferences in CVG, where they can also originated by the interaction among the intermediates that are formed during

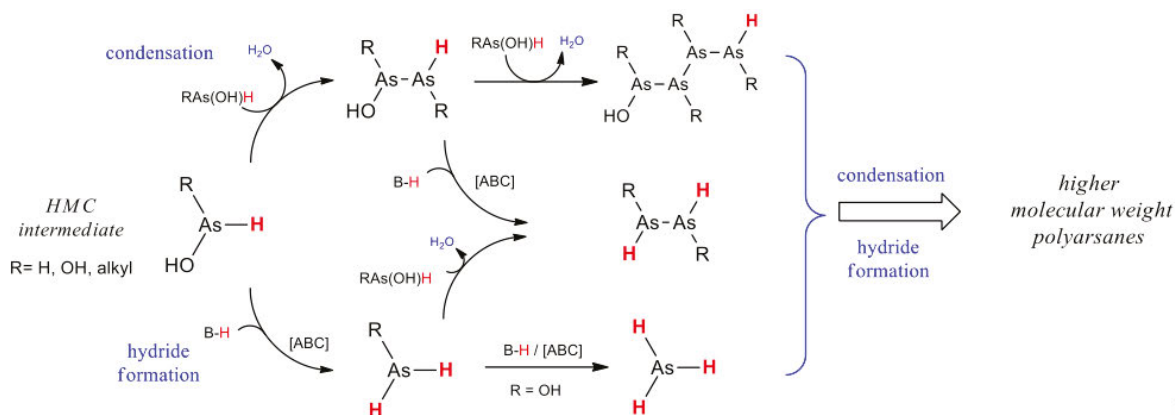


Figure 2. Competition between hydride formation and condensation reactions involving an HMC intermediate. Reproduced from A. D'Ulivo, The contribution of chemical vapor generation coupled with atomic or mass spectrometry to the comprehension of the chemistry of aqueous boranes, *J. Anal. At. Spectrom.* 34 (2019) 823_827 [19], with permission of The Royal Society of Chemistry.

reaction of both the analyte and the interferent with the borane/B-H species.

4. Fundamental aspects of VG techniques

Since 2003, almost simultaneously with the beginning of studies on the mechanisms governing CVG (section 3), numerous alternative techniques have

been developed and established that have provided further impetus to renew the interest and use of these techniques. In CVG, derivatization reactions have been extended to the generation of alkyl derivatives and volatile chelates. Furthermore, new 'greener' techniques, which allow the elimination of most reagents, such as photochemical, thermochemical, sonochemical and

Year	Description and comments	Reference*
2011	Deuterium labelled experiments disclose the occurrence of a " <i>mechanistic interference</i> " generated by Au ^{III} , Rh ^{III} , Pt ^{II} and Pd ^{II} aqueous ions, which interfere with the process of hydrogen transfer from boron to analyte. These metal ions can promote the incorporation of large amount fraction of hydrogen from the aqueous reaction environment to final hydride.	[1, 2]
2012	The direct, stepwise mechanism of hydrogen transfer was confirmed also for pentavalent As species, Me _n AsVO(OH) _{3-n} (n=0,1,2) under analytical conditions.	[2,3]
2014	Studies under non-analytical reaction conditions discloses the formation of polyarsanes due to condensation reactions.	[4]
	Definition of a more general reaction model for CVG based on the competition between hydrogen transfer and condensation reactions.	
2014	Application of the acquired knowledge on the mechanisms of CVG to the speciation analysis of As. Studies on reactivity modification using ammonia borane and L-cysteine in different reaction media.	[5]
2016	Critical evaluation of the state of knowledge on mechanisms and fundamental aspects of GCV. Definition of more general reaction models.	[6]
2016	Application of the acquired knowledge on the mechanisms of CVG to the speciation analysis of As. Evidence of demethylation of As species during THB derivatization. The extent of demethylation decrease passing from BH ₄ ⁻ to its hydrolysis products: BH ₃ L < BH ₂ L ₂ < BHL ₃ (L=OH, H ₂ O etc; charge omitted).	[7]
2018	Determination of As-sugars by THB derivatization and investigation of related mechanism. The generation of methylated arsanes from As-sugars passes through the reversible formation of analyte-borane complex intermediates (ABC).	[8]
2018	Application of the acquired knowledge on the mechanisms of CVG to study of the mechanisms controlling the generation of volatile Cd species. Use of THB and its hydrolysis intermediate BH ₃ OH ⁻ .	[9]
2018	Study of the mechanism of action of additives in CVG. The role of iodide and thiocyanate in the generation of H ₂ Se by THB and ammonia borane.	[10]
2018	Study of the mechanisms of CVG of hydrogen selenide by THB and amine boranes.	[11]
2019	The anomalous behavior of amine boranes during hydrolysis in strongly acidic media.	[13]
	Identification of hydrolysis products of amine boranes and revision of the mechanism of hydrolysis which is commonly accepted in the literature	
2019	Critical evaluation of the state of knowledge on mechanisms and fundamental aspects of GCV.	[13]
2022	A book reports and discusses fundamental aspects of VG techniques including: • chemical-, electrochemical-, photochemical-, sonochemical-, thermochemical- and plasma induced-vapor generation; • atomization devices for VG techniques.	[14]

(*) see: <https://iupac.org/project/2007-041-1-500/>

Table 1. Summary of studies related to the mechanisms of CVG by aqueous boranes after 2011.

plasma mediated VG techniques have been added to the already existing techniques of chemical and electrochemical derivatization. The VGTs which are until now available, allow the derivatization to volatile species of a significant number of elements:

Be, N, F, Si, P, S, Cl, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Y, Mo, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb, Te, I, Lanthanoids (except Pm), W, Os, Ir, Pt, Au, Hg, Tl, Pb and Bi.

In spite of numerous applications, very few efforts have focused on understanding the fundamental processes governing the derivatization reactions associated with the various VGTs. Sources of information unfortunately remain mostly fragmented in many papers published across a spectrum of scientific journals.

From these considerations the stimulus was born to bring together in a single work the existing information on the fundamental aspects of VGTs. The results of this effort are reported in a new book, *Vapor Generation Techniques for Trace Element Analysis: Fundamental Aspects*. (Elsevier, 2022)

The book is devoted to a comprehensive coverage of the fundamental aspects of VGTs, encompassing methodologies ranging from the classical chemical approaches to the most recent frontiers and presents a thorough overview and critical discussion of the state-of-the-art of knowledge of the mechanisms that control

the generation of volatile derivatives and their atomization/detection by atomic spectrometry.

Recently, the use of CVG techniques, in particular those using aqueous boranes, is being increasingly replaced with other greener techniques, in particular photochemical VG. This is due to the lower use of reactants, fewer interfering effects, and the possibility of derivatizing new elements that are inactive or difficult to derivatize by CVG techniques. Nevertheless, the fundamental studies on CVG with aqueous boranes have contributed not only to improve the applicative aspects of CVG but they also represent a contribution to the understanding of the chemistry of aqueous boranes.

Some aspects of CVG still remain controversial, for example the role played by some additives and interferents. As well, greater efforts must be directed to the identification of many volatile derivatives of noble and transition metals, which hinders further advances in the understanding of the mechanisms governing CVG and in general that of VGTs.

<https://iupac.org/project/2007-041-1-500/>

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IUPAC Provisional Recommendations

Provisional Recommendations are preliminary drafts of IUPAC recommendations. These drafts encompass topics including terminology, nomenclature, and symbols. Following approval, the final recommendations are published in IUPAC's journal *Pure and Applied Chemistry* (PAC) or in IUPAC books. During the commentary period for Provisional Recommendations, interested parties are encouraged to suggest revisions to the recommendation's author. <https://iupac.org/recommendations/under-review-by-the-public/>

Definition of the Pnictogen Bond

This recommendation proposes a definition for the term "pnictogen bond": the term pnictogen bond designates a subset of the attractive interactions between an electrophilic region on a pnictogen atom in a molecular entity and a nucleophilic region in another, or the same, molecular entity.

Corresponding Author: Giuseppe Resnati <giuseppe.resnati@polimi.it>

Comments by 31 May 2023

Reference materials for phase equilibrium studies. 2. Solid–liquid equilibria (IUPAC Technical Report)

Ala Bazyleva, et al

Pure and Applied Chemistry, 2022

Vol. 94, no. 11-12, pp. 1225-1247

<https://doi.org/10.1515/pac-2021-1002>

This article is the second of three projected IUPAC Technical Reports on reference materials for phase equilibrium studies. The goal of this project was to select reference systems with critically evaluated property values for the verification of instruments and techniques used in phase equilibrium studies of mixtures. This report proposes seven systems for solid–liquid equilibrium studies, covering the four most common categories of binary mixtures: aqueous systems with organic solutes, aqueous systems with inorganic solutes, non-aqueous systems, and systems with low solubility. For each system, the available literature sources, accepted data, smoothing equations, and estimated uncertainties are given.

<https://iupac.org/project/2011-037-2-100/>

Methods for the SI-traceable value assignment of the purity of organic compounds (IUPAC Technical Report)

Steven Westwood, et al

Pure and Applied Chemistry, 2023

Vol. 95, no. 1, pp. 1-77

<https://doi.org/10.1515/pac-2020-0804>

The “purity” of an organic compound typically refers, in practice, to an assignment of the mass fraction content of the primary organic component present in the material. The “purity” value of an organic primary calibrator material is the ultimate source of metrological traceability of any quantitative measurement of the content of that compound in a given matrix. The primary calibrator may consist of a Certified Reference Material (CRM) whose purity has been assigned by the CRM producer

or a laboratory may choose to value-assign a material to the extent necessary for their intended application by using appropriately valid methods. This report provides an overview of the approach, performance and applicability of the principal methods used to determine organic purity including mass balance, quantitative NMR, thermal methods and direct-assay techniques. A statistical section reviews best practice for combination of data, value assignment as the upper limit values corresponding to 100 % purity are approached and how to report and propagate the standard uncertainty associated with the assigned values.

<https://iupac.org/project/2013-025-2-500/>

Minimum requirements for publishing hydrogen, carbon, nitrogen, oxygen and sulfur stable-isotope delta results (IUPAC Technical Report)

Grzegorz Skrzypek, et al

Pure and Applied Chemistry, 2022

Vol. 94, no. 11-12, pp. 1249-1255

<https://doi.org/10.1515/pac-2021-1108>

Stable hydrogen, carbon, nitrogen, oxygen and sulfur (HCNOS) isotope compositions expressed as isotope-delta values are typically reported relative to international standards such as Vienna Standard Mean Ocean Water (VSMOW), Vienna Pee Dee belemnite (VPDB) or Vienna Cañon Diablo Troilite (VCDT). These international standards are chosen by convention and the calibration methods used to realise them in practice undergo occasional changes. To ensure longevity and reusability of published data, a comprehensive description of (1) analytical procedure, (2) traceability, (3) data processing, and (4) uncertainty evaluation is required. Following earlier IUPAC documents on terminology and notations, this paper proposes minimum requirements for publishing HCNOS stable-isotope delta results. Each of the requirements are presented with illustrative examples

<https://iupac.org/project/2020-013-1-200/>

The IUPAC Orange Book—it's all about the journey

by Brynn Hibbert

The 20th century English conductor Sir Thomas Beecham is credited (probably incorrectly) with the advice: “Try anything once, except incest and Morris dancing¹”. After reading this, you may wish to add “editing IUPAC Color Books.” Or not.

The journey starts

The minutes of the Officers' meeting of the Analytical Chemistry Division (ACD) held in Beijing in November 2008 read “The officers discussed this issue [the lack of consistency of the 3rd edition of the Orange Book] at their meeting in Beijing, based on a report from the Secretary [D B Hibbert], and came to the conclusion that ACD should go for a complete updating of the Orange Book. This demanding task will involve all the division members. In particular, all the Titular Members will be involved in the revision of the Orange Book, each taking the responsibility for a sub-project.” This was confirmed at the General Assembly in Glasgow in 2009. As Secretary, and about to become Vice President, President and then Past President, it was thought that the six years of senior office would be more than sufficient to complete the project. (Ha, ha!)

IUPAC Color Books

To remind us, in addition to *Pure and Applied Chemistry* Recommendations, IUPAC has been publishing its terminology and nomenclature work as books for many years. The earliest appears to be the first edition of the Red Book (Inorganic nomenclature) in 1958. In 1987 it was decided to bring together terminology into a single text, called the Gold Book, not because of the importance of the colour, but after Professor Victor Gold, Daniell Professor of Chemistry at King's College London². The 1997 Gold Book was published as a series of pdfs ‘on-line’ in 2003, (<https://old.iupac.org/publications/compendium/>) and this gave the impetus for the xml Gold Book that became the signature version in 2006 until the latest ‘Web 3.0’ revision replaced it in 2019 (The IUPAC Compendium of Chemical Terminology, <https://goldbook.iupac.org>).

The first edition of the Orange Book was in 1977, and the 3rd edition in 1997. An on-line version which

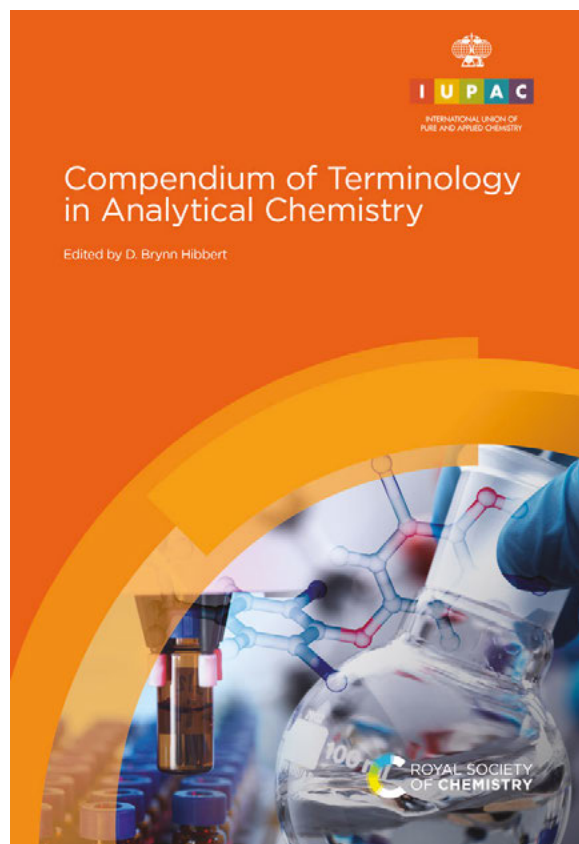


Figure 1: Front cover of “Compendium of Terminology in Analytical Chemistry, 4th edn” – “the Orange Book.” <https://iupac.org/what-we-do/books/orangebook/>

could be downloaded as a hyperlinked pdf was published in 2009, the year the decision was made to embark on the 4th edition [1].

The Orange Book to 2009

The First Edition was published in 1977 edited by the legendary H.M.N.H. Irving, H. Freiser and T.S. West. It was a collection of 23 reports published by IUPAC between 1960 and 1976. The Compendium was updated as the second edition in 1987 by the 11 reports published between 1976 and 1984.

Although mostly keeping the structure of the original editions, the 1997 third edition, edited by János Inczédy, was a major revision [2]. There were three new chapters: selections from the Green Book, [3] a chapter on quality assurance, and a chapter on applications. However, a report on the 3rd edition wrote:

¹ A kind of English country dancing involving bells tied around the legs and silly hats.

² And by curious coincidence the Head of Department when I was an undergraduate and postgraduate from 1969 – 1976. I never realised his IUPAC connections.



The ACD Officers meeting in Beijing in November 2008: President Ales Fajgelj (4th from right), Vice President Walter Lund (3rd from right), Past President Ryszard Lobinski (at left or 1st from right), and Secretary Brynn Hibbert (5th from right). Among the hosts is Zhifang Chai (6th from right).

Table 1: IUPAC color books. (see also <https://iupac.org/what-we-do/books/color-books/>) Several color books have also been published on the web. The Gold Book has been web only since 2006. ¹ Pre-Green Book, “Manual of Symbols and Terminology for Physicochemical Quantities and Units”

Year	Book
1958	Red
1969	Green ¹
1973	Green ¹
1976	Green ¹
1977	Orange
1979	Blue
1987	Orange
1987	Gold
1988	Green
1990	Red I
1991	Purple
1992	White
1993	Blue
1993	Green
1995	Silver
1997	Orange
1997	Gold
2001	Red II
2005	Red
2006	(Gold online)
2008	Green
2009	Purple
2013	Blue
2016	Silver
2019	(Gold online)
2023	Orange
2023	Abridged Green

“Unfortunately, the Orange Book does not have a consistent structure. Some chapters are written like a textbook while others have a glossary format. In some cases, an alphabetical order of the terms is maintained within each paragraph.” (ACD Teamwork, March 2009, from <https://iupac.org/body/500>). This was the issue, along with the eleven-year gap, that triggered the discussion in Beijing in 2008.

Decisions, decisions

The overall stewardship of the project was given to me, but members of the Division Committee would be asked to look after particular chapters.

Having decided to more or less start from scratch with the 4th edition, two further decisions had to be made. First, what was to be included—and more contentiously—excluded. We were amazed that, in fact, analytical chemistry had moved a long way since 1997. Whole new areas such as statistics and experimental design needed inclusion, and traditional fields of spectroscopy (particularly NMR) and chromatography had burgeoned. Very quickly it was decided to stick to the terminology of principles and methods, and not have applications (as was found in the 3rd edition). There were simply not enough pages to include a sensible selection. So, in came a first chapter on

fundamental metrology and a last chapter on modern quality assurance. This added to a new chapter on chemometrics.

Secondly, the preparation of an entire book from scratch that would contain definitive terminology would have been a review nightmare. We therefore decided that each chapter would be prepared as a PAC Recommendation. The idea was that then the accepted and fully-reviewed terms could be easily moved into the Orange Book. This was a good idea and eventually saved the project from falling in a heap, but the execution of the transfer turned out to be a bit more complicated than we hoped.

Table 2 gives the published Recommendations (and one Technical Report). Two were published as separate projects outside the Orange Book; mass

spectrometry #7 and thermal methods #11. The remaining ten Recommendations appeared between 2016 and 2021.

Why did it take so long?

Zhifang Chai won the prize for being the first to submit his chapter on Radioanalytical methods to the Division in 2011. However, the Recommendation was not published until 2021, after some debate among different groups in the radioanalytical community. The first Recommendation actually published was Janusz Pawliszyn's paper on sample extraction in 2016 (and a Technical Report to go with it), closely followed by the chemometrics Recommendation. The rest dribbled in over the next five years. We had three deaths of people leading chapter projects, including Paul De Bièvre, to

Chapter	IUPAC Recommendation/ Technical Report
1, 13	Hibbert DB, Korte E-H, Örnemark U. Metrological and quality concepts in analytical chemistry (IUPAC Recommendations 2021). <i>Pure Appl Chem.</i> 2021; 93 (9):997–1048.
2	Hibbert DB. Vocabulary of concepts and terms in chemometrics (IUPAC Recommendations 2016). <i>Pure Appl Chem.</i> 2016; 88 (4):407–443.
3	Poole C, Mester Z, Miró M, Pedersen-Bjergaard S, Pawliszyn J. Glossary of terms used in extraction (IUPAC Recommendations 2016). <i>Pure Appl Chem.</i> 2016; 88 (5):517–558. Poole C, Mester Z, Miró M, Pedersen-Bjergaard S, Pawliszyn J. Extraction for analytical scale sample preparation (IUPAC Technical Report). <i>Pure Appl Chem.</i> 2016; 88 (7):649–687.
4	Camões M, F., Christian G, D., Hibbert DB. Mass and volume in analytical chemistry (IUPAC Technical Report). <i>Pure Appl Chem.</i> 2018; 90 (3):563–602.
5	Maryutina TA, Savonina EY, Fedotov PS, Smith RM, Siren H, Hibbert DB. Terminology of separation methods (IUPAC Recommendations 2017). <i>Pure Appl Chem.</i> 2018; 90 (1):181–231.
6	Infante, H. G.; Warren, J.; Chalmers, J.; Dent, G.; Todoli, J. L.; Collingwood, J.; Telling, N.; Resano, M.; Limbeck, A.; Schoenberger, T.; Hibbert, D. B.; LeGresley, A.; Adams, K.; Craston, D.: Glossary of methods and terms used in analytical spectroscopy (IUPAC Recommendations 2021). <i>Pure Appl Chem.</i> 2021; 93 (6):647–776.
7	Murray KK, Boyd RK, Eberlin MN, Langley GJ, Li L, Naito Y. Definitions of terms relating to mass spectrometry (IUPAC Recommendations 2013). <i>Pure Appl Chem.</i> 2013; 85 (7):1515–1609.
8	Pingarrón, J. M.; Labuda, J.; Barek, J.; Brett, C. M. A.; Camões, M. F.; Fojta, M.; Hibbert, D. B.: Terminology of electrochemical methods of analysis (IUPAC Recommendations 2019). <i>Pure Appl Chem.</i> 2020; 92 (4):641–694.
9	Chai Z, Chatt A, Bode P, Kucera J, Greenberg R, Hibbert DB. Terminology of radioanalytical methods (IUPAC Recommendations 2020). <i>Pure Appl Chem.</i> 2021; 93 (1):69–111.
10	Takeuchi T, McQuillan J, Shard A, Russell A, Hibbert DB. Glossary of methods and terms used in surface chemical analysis (IUPAC Recommendations 2020). <i>Pure Appl Chem.</i> 2020; 92 (11):1781–1860.
11	Lever T, Haines P, Rouquerol J, Charsley Edward L, Van Eckeren P, Burlett DJ. ICTAC nomenclature of thermal analysis (IUPAC Recommendations 2014). <i>Pure Appl Chem.</i> 2014; 86 (4):545–553.
12	Labuda, J.; Bowater, R. P.; Fojta, M.; Gauglitz, G.; Glatz, Z.; Hapala, I.; Havliš, J.; Kilar, F.; Kilar, A.; Malinová, L.; Sirén, H. M. M.; Skládal, P.; Torta, F.; Valachovič, M.; Wimmerová, M.; Zdráhal, Z.; Hibbert, D. B.: Terminology of bioanalytical methods (IUPAC Recommendations 2018). <i>Pure Appl Chem.</i> 2018; 90 (7):1121–1198.

Table 2: Chapters of the Orange Book and their Recommendations

whom the Orange Book is dedicated; one member of the Division committee (I shall not name him) totally withdrawing after several years of coming to meetings saying his chapter was nearly finished—any day soon; and a couple of chapters that lingered in the PAC editorial system perhaps a tad longer than necessary. With the impending completion of all Recommendations a contract was signed to deliver a manuscript to the RSC in 2021. This happened on April 1st to be followed by a retraction because not all chapters had been appropriately reviewed. Careful and quick work by the Division, and an equally speedy and thorough, review by ICTNS, allowed a second submission of the manuscript on 19th May 2022. There followed rounds of proofs and some discussion, with the final file sent to the publishers on 25th October 2022. The Orange Book was published on 27th January 2023.

So what took so long? Nothing really—this is how long these kinds of projects take.

Editors ... and editors

It might be thought that the job of an editor is to collect the chapters, make sure they are sensible and bring them together in a nice order for publication. This turns out not to be the case for a Color Book. Even with a published Recommendation the order of terms might need amending, duplications (surprisingly many) must be resolved, introductions to chapters harmonized and finally an index of terms and symbols created. Learning a lot about writing terminologies, I found myself a co-author on eight Recommendations in addition to writing the Recommendation for Chapter 2, so here the title 'editor' covers a bit more than usual.

What next?

There is life after a Color Book—another Color Book. For me, it is working with Stuart Chalk on the massive Gold Book project. The Orange Book and its Recommendations came at a good time to try out the

new Term Review System (TRS) for transporting entries into the Gold Book. This, like the Orange Book, will take as long as it takes, but when it is finished IUPAC will be the better for it, and will have fulfilled its mission to be “the world authority on chemical nomenclature and terminology.”

Acknowledgements

The list of 57 people who contributed to the Orange Book may be found in the front matter of the book. To this must be added the IUPAC secretariat and new friends in the RSC. Some have contributed more than others, and have been thanked, but the Orange Book was a team effort and the winner is IUPAC.

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3. E. R. Cohen, T. Cvitaš, J. G. Frey, B. Holmström, K. Kuchitsu, R. Marquardt, I. Mills, F. Pavese, M. Quack, J. Stohner, H. L. Strauss, M. Tamaki, A. Thor. *Quantities, Units and Symbols in Physical Chemistry, IUPAC Green Book, 3rd edition*. The Royal Society of Chemistry, Cambridge, UK (2007).
4. IUPAC. *Compendium of Chemical Terminology, IUPAC Gold Book, 2nd edition. Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997); Web 2.0 version by Stuart Chalk 2019. <http://goldbook.iupac.org> accessed 10/10/2022.*

Brynn Hibbert is Secretary of ICTNS and editor of the *Compendium of Terminology in Analytical Chemistry*, 4th edn 2023, The Royal Society of Chemistry, UK. He is Emeritus Professor of Analytical Chemistry at UNSW, Sydney and Emeritus Fellow of IUPAC Analytical Division.

<https://iupac.org/what-we-do/books/orangebook/>
or <https://doi.org/10.1039/9781788012881>

Preparation, formatting and review of IUPAC Technical Reports and Recommendations, IUPAC-sponsored books, or other items carrying the IUPAC label

Prepared for publication by Jan Kaiser, David Brynn Hibbert and Jürgen Stohner

All guidelines proposed by the Interdivisional Committee on Terminology, Nomenclature and Symbols (ICTNS) for the preparation, formatting and review of IUPAC documents have been reviewed and compiled in one single document now directly available in PAC: <https://doi.org/10.1515/pac-2022-1106> (*Pure Appl. Chem.*, vol. 94, no. 11-12, 2022, pp. 1257-1267)

IUPAC Chemistry and the Environment Division meets Cambodia

by Roberto Terzano, Fani Sakellariadou, Doo Soo Chung, and Annemieke Farenhorst

The week of 5-10 November 2022 turned out to be a very intense and exciting time for Division VI – Chemistry and the Environment. For six days, Division Members, Young Observers and Guests were involved in many scientific and social events in Siem Reap, Cambodia. This series of events arrived after a long break of in-person activities due to the COVID-19 pandemic and therefore was of particular significance for the IUPAC Division VI community.

The occasion was provided by the Joint Conference organized in Siem Reap with the endorsement of four scientific societies APCE, CECE, ITP and of course, IUPAC. Division VI Member Doo Soo Chung, as Co-Chair of the Conference, offered Division VI the opportunity to organize Division activities within the Conference venue and scientific program.

Division VI participation in the Conference was partially supported by IUPAC (#2020-003-1-FSC for Conferences in Scientifically Emerging Region (SER)). The motivation that inspired this project was that very often emerging regions suffer from environmental pollution and related health issues due to improper waste management, including disposal of chemicals. A proper identification, quantification and risk assessment of

such chemicals, especially emerging contaminants, is fundamental to secure a safe and healthy environment. Within this context, Division VI contributed by sharing its knowledge on these topics with the local scientific community and local University. In addition, Cambodia is not yet part of the National Adhering Organizations of IUPAC and, in fact, its Chemical Society is only newly founded (2010). Hence, the visit of IUPAC Division VI was an important opportunity to promote IUPAC in the Region.

On Saturday 5 November, we had our first Division meeting in-person at the Sokha Siem Resort, long after the last one that took place in August 2019 in Paris during the General Assembly of the IUPAC Centenary. We had the opportunity to discuss face-to-face one whole day about Division agenda items, including brainstorming new project ideas. On this occasion, also the two Subcommittees on Crop Protection Chemistry and Biophysical and Chemical Processes in the Environment had the chance to meet as small groups. The working day ended with the Division dinner in a local restaurant, which allowed the Group to reconsolidate old relationships and establish new ones.

IUPAC Overview Session

On Sunday 6 November, Division VI organized a preconference Symposium about IUPAC and Division VI activities entitled “*IUPAC Overview Session*.” In this Session, Division VI President Roberto Terzano introduced to the audience IUPAC and IUPAC activities with

IUPAC Division VI meeting at the Sokha Siem Reap Resort and Conference Center in Siem Reap, Cambodia





Group picture after the "IUPAC Overview Session" at the Sokha Siem Reap Resort and Conference Center in Siem Reap, Cambodia

a special focus on Division VI organization and projects. Then, Bipul Behari Saha gave a presentation on "A brief history of IUPAC," followed by Hemda Garelick's presentation on "The Global Women's Breakfast." After this general introduction, three recently started projects were introduced through a number of presentations: "The global scenario and challenges of radioactive waste in the marine environment" (project #2021-027-2-600), "Carbon sequestration: Harmonizing carbon sequestration measurement – what does it mean and how we do it" (project #2022-010-2-600) and "Minimizing Environmental Impacts of Tyre and Road Wear Particles" (project #2021-028-3-600). Presentations were held by Nicholas Priest, Diane Purchase, Michelle Bailey, Divina Navarro and Lokesh Padye.

On Monday 7 November, two Special Symposia were organized within the Conference program, one about "The Environment, Health and Food Safety Impact of Microplastics" (project #2019-026-2-600) and one on "Per and polyfluoroalkyl substances (PFASs) in the environment: Information for emerging economies on PFASs analyses in environmental media and their impacts on human health" (project #2019-029-1-600). (see separate next reports p. 40 and 42) During the week, Division Members had also the opportunity to meet in project task groups and discuss about ongoing projects and planning next projects activities.

On Thursday 10 November, Angkor University hosted the event titled "Chemistry and the Environment: IUPAC Contribution to Emerging Environmental Issues," organized by Division VI and the Angkor University. Roberto Terzano presented on the vision,

mission and values as well as the history of IUPAC, and its responsibility and activities. Dr. Terzano highlighted that IUPAC is the authority on chemical nomenclature and terminology and recommends on standardized methods that are of essence to the global Chemistry community. IUPAC has eight Divisions and much of the scientific work within and between Divisions is done through collaborative projects that result in databases, technical reports, journal articles, and books. Hemda Garelick expanded on the importance of IUPAC in connecting chemists and their affiliates across the world by hosting the IUPAC Global Women's Breakfast (iupac.org/gwb). Ankor University has large strengths in Health Sciences education and hence Garelick also provided an opportunity for the audience to learn about the history of antibiotics and their mechanisms, and also about how bacteria can acquire antimicrobial resistance.

Speakers Rai Kookana and Fani Sakellariadou provided for examples of topics covered by IUPAC Division VI projects. Kookana presented on per and polyfluoroalkyl substances (PFAS) in the environment, particularly this being an emerging issue for developing economies. The audience learned about the sources of PFAS and why they are so problematic in the environment (e.g., persistent, mobile). Kookana also provided a wide range of examples of studies reporting PFAS detections in Asian waters. Sakellariadou presented on microplastics, focusing on the marine environment. The audience learned about a variety of in-depth studies on the size and weight of plastics in surface waters such as the Atlantic Ocean, Pacific Ocean, and Mediterranean



Group picture at the Angkor University (Siem Reap, Cambodia) after the event “Chemistry and the Environment: IUPAC Contribution to Emerging Environmental Issues.”

Sea. Sakellariadou warned the audience that by 2050, the weight of plastics might exceed the weight of fish in the oceans. The audience also learned that microplastics can be found along all coast lines in the world and are particularly abundant on the shores of Asian waters. Given that Angkor University has a strong focus on agriculture, Diane Purchase and Annemieke Farenhorst focused their presentations on this area. Purchase provided for an overview of the valorization of agricultural wastes. Purchase talked about the different types of natural and synthetic agricultural wastes and their impact. In addition, a case study was presented showing that some agricultural wastes can be used such as xylitol, a substitute for sugar. Farenhorst presented on agricultural pesticides, going all the way back to about 4,700 years ago when sulfur was first reported as a tool to prevent rodent outbreaks in spaces inhabited by humans. Farenhorst discussed current-pesticides use and their fate processes, and highlighted some examples by which we can protect the environment from pesticide contamination. As such, the audience also learned about communities organizing the recycling of empty pesticide containers, and individual farmers using biobeds to capture their sprayer rinsate.

At the end of the day, the Rector of the Angkor University awarded all the speakers from Division VI

with a certificate of appreciation and expressed his interest in further collaboration with IUPAC in the interest of the local scientific community.

by Roberto Terzano (University of Bari, Italy), Fani Sakellariadou (University of Piraeus, Greece), Doo Soo Chung (Seoul National University, South Korea), Annemieke Farenhorst (University of Manitoba, Canada)

Tackling the global microplastic challenge

by Hemda Garelick and Weiping Wu

On 7 November 2022, as part of the APCE-CECE-ITP-IUPAC 2022 Conference in the Sokha Siem Resort and Conference Center of Siem Reap, Cambodia, the IUPAC Division VI held a symposium entitled “*The Environment, Health and Food Safety Impact of Microplastics*.” The aim of this meeting was to bring scientists together to discuss this emerging pollutant and consider new solutions on how to tackle this challenge.

In recent years, microplastics have been recognized as a global problem. Microplastics have been detected in environmental compartments such as soil, freshwater, and oceans. They were also found in food, drinking water, and human bodies. However, their impacts on the environment,

Conference Call



Pictures of the speakers at the Symposium “The Environment, Health and Food Safety Impact of Microplastics” in Siem Reap, Cambodia. Above, Lokesh P. Padhye and to the right: Diane Purchase.



human health, or food safety are not fully understood yet. More research and new solutions are needed to address the rise in microplastic pollution worldwide.

This symposium is part of IUPAC Project #2019-026-2-600 “The Environment, Health and Food Safety Impact of Microplastics” led by Weiping Wu, Shanghai

Microplastic pollution in the marine environment

Fani Sakellariadou (University of Piraeus, Greece)

Photodegradation of HDPE and assessing its contribution to microplastic pollution in coastal waters

Lokesh P. Padhye (University of Auckland, New Zealand)

Recent advances in the analysis and impact of microplastics in food

Clementina Vitali (Wageningen University, The Netherlands)

Status of microplastics in India

Bipul Behari Saha (Sagar Group of Institutions, India)

An overview of the technologies for microplastic remediation

Diane Purchase (Middlesex University, UK)

Microplastics contamination and their impacts in soil ecosystems

Balwant Singh (University of Sydney, Australia)

We need easy and feasible methods to quantify microplastics in drinking water or wastewater

Hyunook Kim (University of Seoul, South Korea)

Pyrolysis-GC/MSxMS for monitoring of microplastic contamination in plastic recycling work places

Roland Kallenborn (Norwegian University of Life Sciences, Norway)

Pesticide sorption by microplastics and other constituents in Prairie rivers

Annemieke Farenhorst (University of Manitoba, Canada)

From macroplastics to nanoplastics: the presence of plastic particles in personal hygiene products and their possible impact on the environment and on human health

Hemda Garelick (Middlesex University, UK)

Lectures presented at the symposium “The Environment, Health and Food Safety Impact of Microplastics” on 7 Nov. 2022.

Institute of Optics and Fine Mechanics, China. The project is bringing together polymer experts, analytical chemists, environmental scientists, and a diversity of stakeholders and experts from all areas to work together on this important, interdisciplinary topic.

The symposium was chaired by Hemda Garelick from Middlesex University, UK. Fani Sakellariadou from the University of Piraeus, Greece gave a keynote talk titled *"Microplastic pollution in the marine environment."* Balwant Singh from the University of Sydney (Australia) delivered an invited talk on "Microplastics contamination and their impacts in soil ecosystems." Different views on the challenges of microplastics were presented – see program summarized in the table.

Various topics including plastic product innovation, industrial leadership with extender producer responsibility, advanced plastic waste remediation and recycling techniques, diversified plastic waste management systems, together with strong commitments from local and international organizations and governments were discussed. The symposium outcomes will provide a scientific base to support the understandings and actions to prevent and reduce microplastic pollution and enhance the safety of humans, aquatic animals and the ecosystem. The symposium along with the IUPAC microplastic project will strengthen the role of IUPAC in contributing to solving environmental problems and enhancing the quality of food and life on a global scale.

<https://iupac.org/project/2019-026-2-600/>

Poly- and perfluoroalkyl substances (PFAS) in the environment

by Melanie Kah and Rai Kookana

Per- and polyfluoroalkyl substances (PFAS) are a major environmental concern globally due to their widespread usage and persistence. They found widespread applications in industry due to their unique chemistry of having both hydrophilic and hydrophobic (surfactant-like) properties. However, concerns about these chemicals have been growing due to their long-term persistence in the environment, potential for bioaccumulation and toxicity to human and ecological health.

In 2001, when it was realized that PFASs are bioaccumulative, PFAS production started to be phased out in Western Countries. However, it continued in Asia thus shifting the problem to emerging economies. Unfortunately, the true extent of PFAS problem has not

been yet recognized in the emerging economies and this may become a serious issue for the local environments and population.

With the aim of raising awareness around this important environmental issue, IUPAC Division VI held a symposium on "Poly- and Perfluoroalkyl Substances (PFAS) in the Environment" on Monday 7 November 2022 in Siem Reap (Cambodia) as part of the APCE-CECE-ITP-IUPAC 2022 Conference.

This symposium was part of IUPAC Project 2019-029-1-600 *"Per and polyfluoroalkyl substances (PFASs) in the environment: Information for emerging economies on PFASs analyses in environmental media and their impacts on human health"* led by Melanie Kah of the University of Auckland, New Zealand. The project, through a multidisciplinary approach, aims at coping with three overarching aspects around PFAS, namely: analytical chemistry in environmental media, human health effects from environmental exposure, and PFAS management response by regulatory and policy agencies.

At the PFAS symposium, nine speakers represented a diversity of perspectives and approaches to tackle the PFAS environmental problem across the USA, Australia, New Zealand, the Philippines, China and Canada.

The first session was chaired by Rai Kookana (CSIRO/ University of Adelaide, Australia) to set the scene by covering general aspects related to the challenges of dealing with contamination with PFAS. Topics included the behaviour of PFAS in soil by the keynote speaker Christopher Higgins (Colorado School of Mines, USA), occurrence and fate in wastewater treatment plants, risk assessment, management, and remediation of PFAS. Other speakers included Karl Bowles (RPS AAP Consulting Pty Ltd), Melanie Kah, Balwant Singh (University of Sydney, Australia), and Divina Navarro (CSIRO/University of Adelaide, Australia).

The second session was chaired by Melanie Kah (IUPAC Project Task Group Chair), and covered aspects more specific to Asia. These included the bio-monitoring work carried out by the keynote speaker, Michael Velarde (University of the Philippines Diliman), an overview on data available on the occurrence of PFAS in soil and water in Asia, and China in particular. Other speakers were Rai Kookana, Guang-Guo Ying (South China Normal University, China) and Zoltan Mester (National Research Council of Canada).

<https://iupac.org/project/2019-029-1-600/>



Participants of the 1st Italian-French International Conference on Magnetic Resonance at the University of Milano Bicocca

1st Italian-French International Conference on Magnetic Resonance in Milan, 2022

by Silvia Borsacchi, Cristina Airoidi, Laurent Delevoye, Marco Geppi

Planned to be held in Milan in September 2020—with the endorsement of IUPAC—the first Italian-French International Conference on Magnetic Resonance unfortunately had to be postponed due to the COVID-19 pandemic. The Italian and French societies for Magnetic Resonance—GIDRM, Gruppo Italiano Discussione Risonanze Magnetiche (www.gidrm.org), and GERM, Groupement d'Etudes de Resonance Magnétique (germ-asso.fr)—organizers of the conference, with the support of the magnetic resonance researchers of the most important scientific institutions of Milan (Università degli Studi di Milano Bicocca, Università di Milano, G. Ronzoni Institute for Chemical and Biochemical Research, Politecnico di Milano, IRCCS San Raffaele Hospital, and Istituto di Scienze e Tecnologie Chimiche SCITEC, CNR) agreed not to transform the conference to an online meeting. They rather preferred to work together for organizing the face-to-face conference in Milan as soon as the health safety conditions could have allowed it.

Finally, this several years-long project, which started from conversations among Italian and French colleagues and that was built during many on-line meetings involving the boards of the two societies and the local organizers, could be realized on 27-30 September 2022, in Milan.

This was the first face-to-face meeting for both Italian and French Magnetic Resonance researchers in more than two years, and it was particularly emotional to have it in Milan, one of the most lively, active,

productive cities in Italy, that was terribly hit by the COVID-19 pandemic.

GIDRM in Italy and GERM in France are the largest no-profit, independent national societies of people (about 900 members in GIDRM and more than 300 regulars in GERM) working on Magnetic Resonances (MR), including NMR (Nuclear Magnetic Resonance) and EPR (Electron Paramagnetic Resonance) spectroscopies, relaxometry, and MRI (Magnetic Resonance Imaging), in public and private organizations. The mission of each society is to support the national community of researchers working on MR, especially the youngest ones, providing grants for research and travelling, giving awards for research careers, Master and PhD theses and best conference presentations, organizing summer schools, workshops and an annual or biennial national scientific meeting for discussing the most relevant research topics in MR. The Italian society GIDRM, with the aim of establishing relations and exchanges with similar societies in other European countries, organized a joint meeting with German and Slovenian Societies in 2013. The GERM society organized joint meetings with Portuguese and Spanish societies in 2016 and 2011, respectively.

GIDRM and GERM Boards and their Presidents, Marco Geppi and Isabelle Landrieu (up to 2021) and Laurent Delevoye, decided to organize the first joint Italian-French International Conference on Magnetic Resonance, with the aim of strengthening the reciprocal knowledge, exchanges and synergies between the two lively and bordering national communities, discussing the most recent developments in the field of magnetic resonances. The active group of GIDRM members, working in several Milan institutions, offered to host the conference at the Università degli Studi di Milano Bicocca and a Local Organizing Committee, headed by



Dave Bryce's (University of Ottawa) lecture.

Cristina Airoidi, worked tirelessly for a successful local logistics.

GIDRM and GERM Boards, as a joint Scientific Committee of the conference, designed a rich scientific program with 8 invited plenary keynote lectures delivered by scientists coming from all continents, 8 invited plenary lectures by distinguished Italian and French scientists and 35 lectures in parallel sessions, selected from the received abstracts.

The panel of keynote and invited speakers was gender balanced and geographically diverse: Alexander Barnes, ETH Zurich, Switzerland; Angelo Bifone, University of Turin, Italy; David Bryce, University of Ottawa, Canada; Roberto Fattorusso, University of Campania, Italy; Patrick Giraudeau, University of Nantes, France; Angela Gronenborn, University of Pittsburgh, USA; Michal Leskes, Weizmann Institute of Science, Israel; José Martins, Ghent University, Belgium; Françoise Ochsenbein, CEA-Saclay, France; Miquel Pons, University of Barcelona, Spain; Hélène Ratiney, CNRS Lyon, France; Daniel Topgaard, University of Lund, Sweden; Paola Turano, University of Florence, Italy; Andrew Webb, University of Leiden, Netherlands (who had to cancel his participation due a last-minute impediment). The talks covered many different cutting-edge magnetic resonance research topics, as latest methodologic developments (hardware and analysis for MR in solids and liquids, in vivo MR spectroscopy and human MR imaging) and especially very innovative applications of MR to the understanding of crucial topics in biochemistry and biology (proteins, lipopeptides, cells, metabolites), human health (imaging diagnosis, medicine) and materials for energy, perfectly representing the great versatility and broad interest of MR.

The Scientific Committee decided to strongly support the attendance of young people, offering to all the

under-35 years old scientists willing to present a contribution, the attendance and accommodation. Moreover, 4 best poster awards were planned to be assigned at the end of the conference and the winners had the opportunity to present their posters in the final plenary session.

Considering the international character of the meeting, the broad interest of the topic, the special attention to young researchers, the Scientific and Local Committees decided to apply for the prestigious IUPAC endorsement, which was granted already in 2020, and maintained for 2022. IUPAC supported the conference with communication on the IUPAC website and an IUPAC representative was invited to deliver a presentation of the union in the conference opening. Silvia Borsacchi, member of the IUPAC CHEMRAWN Committee and of the Italian Commission of CNR (National Research Council of Italy, National Adhering Organization to IUPAC) for IUPAC (www.iupac.cnr.it), and member of the GIDRM Board, presented the union history and mission, from the past to the future, joining the traditional fundamental work on nomenclature and standards with the great present efforts to build a sustainable development, in the many different fields in which chemistry is directly involved, but also toward the superior values of gender equality, education, inclusiveness and peace. The main union activities, as projects, publications, global initiatives, were presented, and all the conference attendees were invited to join IUPAC, offering their volunteering activity to advancing the worldwide role of chemistry for a more sustainable and fair development.

The conference was organized over four days, each of them including keynote and invited talks, and two parallel sessions of oral communications. In each of the first three days of the meeting, a session for

Conference Call

poster presentations (134) was held, during which a committee formed by some keynote and invited speakers (D. Topgaard, D. Bryce, J. Martins, P. Giraudeau, H. Ratiney, P. Turano, A. Bifone) was invited to evaluate posters presented by under-35 students and researchers in order to assign 4 awards the last day of the meeting. The topics presented and discussed at the conference, thanks to the participation and contributions of 256 attendees, covered the most important developments, frontiers, and applications of MR, both in solids, semi-solids, liquids and in-vivo, including Dynamic Nuclear Polarization techniques, spin dynamics and relaxation, low-field MR, investigations on innovative materials, biomolecules, metabolomics, cells, drugs, cells, and contrast agents.

Special talks were delivered by the winner of the GIDRM Gold Medal, Piero Sozzani, for his special contribution to MR, especially in the field of solid-state NMR of materials, in Italy and abroad, and by the GIDRM under 35 awardees Veronica Ghini and Alessia Vignoli, for their research in metabolomics for cancer research. Moreover Bruker, Jeol, Stelar, Magritek and Extrabyte, as MR companies sponsoring the conference, offered lectures on new developments in MR techniques and software. At the end of the conference the best poster awards were assigned to Giorgia Ciufolini (1st prize), Sofie Schellinck (2nd prize), Francesca Nerli (3rd prize),



Fig.4 Winners of the best poster awards with the Presidents of GIDRM and GERM. From left to right: Marco Geppi (GIDRM President, Italy), Francesca Nerli (University of Pisa, Italy), Sofie Schellinck Ghent University (Ghent University, Belgium), Giorgia Ciufolini Università degli Studi di Roma Tor Vergata, Italy), Ritchy Leroy (Université de Reims Champagne Ardenne, France), Laurent Delevoye (GERM President, France).

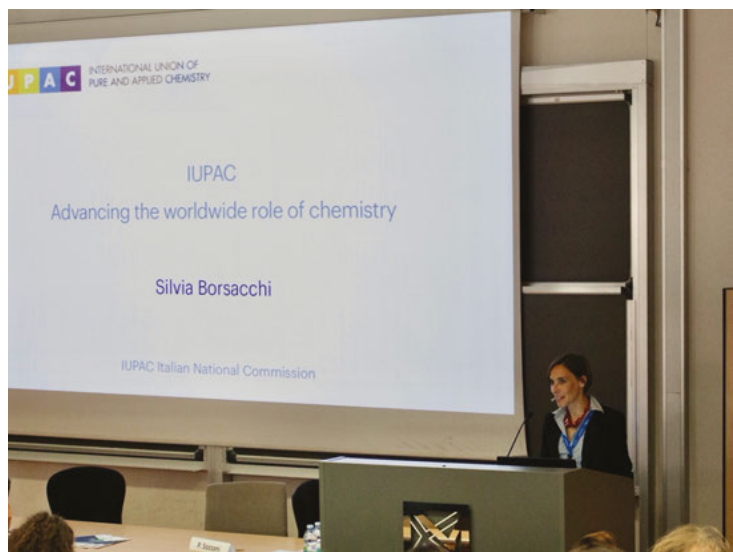


Fig.3 IUPAC presentation delivered by Silvia Borsacchi (CHEMRAWN and Italian NAO).

The conference was closed by the Director of the Department of Biotechnology and Biosciences, Prof. Francesca Granucci and by the Presidents of GIDRM and GERM who jointly acknowledged IUPAC, Università degli Studi di Milano Bicocca, all the sponsors who supported the conference, the Scientific Board and the local organizers of the conference, and especially all the people attending the conference, hoping to have paved the way for future collaborations and meetings.

MR is a great tool for science, an almost uniquely versatile and powerful tool for elucidating the structure, dynamics, and interactions in almost every kind of complex system. Great results have been obtained in more than 70 years of history, but a large potential has still to be developed and this is absolutely necessary for advancing in fundamental fields as materials science, sustainability, medicine and biology.

Silvia Borsacchi, <silvia.borsacchi@pi.iccom.cnr.it> Institute for the Chemistry of OrganoMetallic Compounds, Italian National Research Council (ICCOM-CNR), Pisa, Italy-GIDRM Board member and IUPAC representative at the conference.

Cristina Airoldi, Dept. of Biotechnology and Biosciences, University of Milano – Bicocca, P.zza della Scienza 2, 20126, Milan, Italy-conference chair.
Laurent Delevoye, Université de Lille – Sciences et Technologies UCCS, Bât. C7 - Bureau 128 - 59655 Villeneuve d'Ascq, France-GERM President.
Marco Geppi, Department of Chemistry and Industrial Chemistry, University of Pisa, via G. Moruzzi 13, 56124, Pisa, Italy-GIDRM President

Malta Conferences Foundation, 10th Anniversary Conference: “Knowledge and Society” —MALTA X focus

by Y. Shevah, L. Hogue, C. O'Brien, Z. Lerman

The Malta Conferences Foundation (MCF) is a non-profit NGO association that was founded by Prof. Zafra Lerman as the chair of the Subcommittee on Scientific Freedom and Human Rights of the American Chemical Society (ACS) after 9/11, 2001. MCF aims to promote science diplomacy and chemistry in the Middle East and North Africa (MENA) countries, reaching both regional and national scientists, engineers, consultants, entrepreneurs, educators, media, and researchers from governments, corporations, and academia. MCF offers a science forum for the creation, dissemination, and utilization of knowledge among MENA stakeholders, providing the scientific community and public policy makers with a platform to exchange, discuss and harmonize their ideas in respect to the growing interdependence of science with society. In accordance, MCF has established a series of conferences, taking place biennially in Malta and in other countries, covering the organizational costs and the expenses of selected participants in order to facilitate participation from all Middle East countries, as well as Morocco, and Pakistan. The preparatory tasks of the conference are coordinated by a secretariat, providing continuous access to contact information in-between the conventions, while a Steering Committee selects the principal themes, satellite events and special sessions to be held at the upcoming Conference.

The Conferences are designed based on the following principles and objectives:

1. To provide a forum for dialogue on challenges of science and to communicate science and its basic values to societies at large
2. To promote the mutual understanding of different cultures through scientific dialogue
3. To promote education and distribution of knowledge wealth among the social groups within the various countries in the MENA region
4. To give the participants the possibility to exchange their views regarding the relationship between science and society.

Celebrating the 10th Anniversary of the Malta Conferences

In 2022, marking the 10th anniversary of the MCF series, the Malta X Conference took place in Malta,

November 6-11, 2022, focusing on “**Knowledge and Society**”. During the 5 days conference, more than 100 participants, representing 15 different Middle East countries, Morocco, Pakistan, few representatives from Europe and the US, took part in the event.

The opening ceremony, attended by His Excellency Dr. George Vella, the President of the Republic of Malta and other dignitaries, was followed by keynote addresses by Nobel Laureates, Peter Agre and Aaron Ciechanover and other distinguished scientists. After which, scientists, leaders in government, industry, and NGOs, and the media discussed problems, solutions and challenges to environmental and educational problems common to the region.

Topics and workshops

62 presentations were made under six different workshops, including:

- Water, Energy and Food Security (WEF) Nexus
- Nanoscience, Nano-bioscience, and Nanotechnology
- Medicinal, Organic and Biochemistry, Biophysics, and Biotechnology
- Women in Science
- Chemical, Biological, and Nuclear Security
- Science and Technology Education at All Levels

Water, energy and food security (WEF) nexus

A workshop was devoted to in depth discussion of climate change and impact on water, energy and food security (WEF) nexus, crystallizing the action required on a regional scale, regarding WEF and the connection between regional stability and food security, to fight hunger and food shortage and possible ways to mitigate its worst effects.

Sessions

- Climate, Water Scarcity in a Conflict Region
- WEF Overview & WEF Issues
- Water and Wastewater Treatment & Water Reuse
- Energy: Photovoltaic and Desalination

Objectives

- Raising awareness on Water, Energy, Food (WEF) Nexus and societal impact
- Assessing impacts of climate change and adaptation strategies.
- Analytical tools and technology to identify risks related to WEF
- Resolution of conflict on cross-border co-operation.

Conference Call



The participants of the Malta X Conference. First row, from left to right: Ehud Keinan (President-elect of IUPAC), Agnes Von Der Muhll (French ambassador to Malta), Omar Rifai (Advisor to His Royal Highness Prince El Hassan bin Talal of Jordan), Dr. George Vella (President of the Republic of Malta), Zafra Lerman (MCF President), Peter Agre (2003 Nobel Prize in Chemistry), Frederique Dumas (Former member of the French parliament)

Highlights of the Workshop

- Adverse impact of climate change on WEF
- Regional cross-border and cross-sector collaborations on WEF
- Drinking water quality, wastewater and sanitation aspects and treatment of emerging pollutants
- Ultra-filtration, Nano Technology and molecular biology
- Brackish water desalination, brine treatment and disposal
- Untapped renewable energy resources and agri-voltaic systems

Nature-based solutions

- Use of local materials for water and wastewater treatment towards a more circular economy
- Engineering practices that introduce natural features to promote adaptation and resilience.

Challenges and Potential Collaboration

- The severity of the impacts of climate change and

the speed at which the changes are occurring.

- The urgency and dedication that will be required to manage water in an already changing climate. Business as usual is not an option if we are to achieve the UN SDGs and climate targets
- Degradation of emerging pollutants in aquatic ecosystems, and atmospheric dust deposition
- Region sustainable livelihood, engaging academia, NGOs, women, businesses and corporates.

Nanoscience, Nano-bioscience, and Nanotechnology

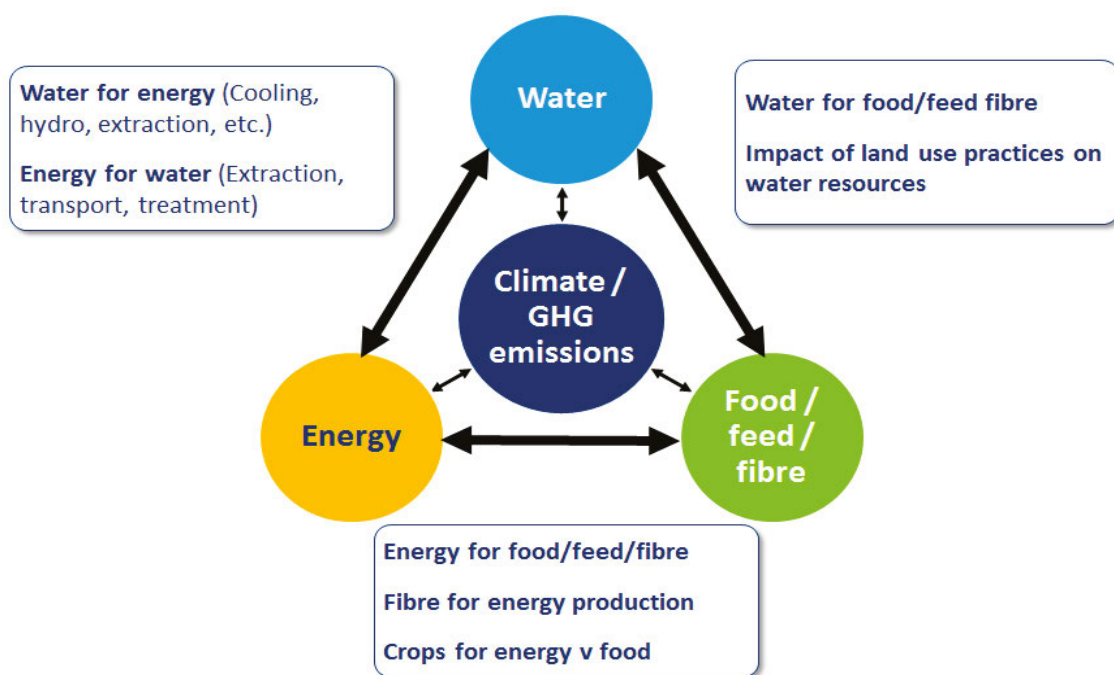
Objectives

- Enhancing plural and multi-disciplinary R&D
- Innovative polymers and nanotechnology research

Highlights of the Workshop

- Bioactive glass nanoparticles (NPs) for bones applications and gelatin NPs for drug delivery

The climate-water-energy-food nexus



Climate, Water, Energy, Food Nexus Diagram. UN 2050 Projection: water +80%; Energy: +55%; Food: + 60% (Source UN, FAO 2011)

- Polymers for detection of bacteria and Carbon nanostructures for heavy metal detection
- Polymers for iodine capture
- Immobilized Catalysts for CO₂ capture
- Ultrafast spin transport via Molybdenum sulfide
- Protein-based metal sensors and cost-effective paper-based sensors

Challenges and Potential Collaborations

- Sustaining collaboration caused by lack of funding
- Collaboration to enhance research quality expanding plural and multi-disciplinary expertise
- Production of materials for potential applications
- Guidance on intellectual property and technology transfer
- Medicinal, Organic and Biochemistry, Biophysics, and Biotechnology

Objectives

- Cross-border collaboration in research and development
- Entrepreneurship stimulation

Highlights of the Workshop

- Platinum (IV) - hydrazide Complexes, as potent lipoxygenase inhibitor

- Therapeutic monoclonal antibodies and antibody fragments to transit from full length immunoglobulins to antibodies mimetics
- SARS-CoV-2 Spike WT structure and O-micron protein trimer and its receptors that may affect entry into human cells
- vitamin D and C- Reactive Protein CRP reaction with COVID- 19 in older Iraqi patients
- Lipid binding, neuronal membrane, oxidative stress and molecular crowding effects on amyloid aggregation
- Microscopic evidence for malaria parasites in viscera tissues of the Medici family
- Challenges and Potential Collaborations
- How to translate scientific ideas into a collaborative and business
- Natural product drug discovery, a model of cross-border collaboration in research

Women in Science

Objectives

- Women's role in scientific research and technology
- Education and dissemination of knowledge wealth among women within MENA region

Conference Call

Highlights of the Workshop

- Gender (in) equality and persisting gaps in STEM Education in the Middle East workplace
- Obstacles that hinder gender equality in STEM education; societal roles, resources, and educational structure and curriculum
- STEM pedagogy based on critical thinking and creativity rather than the traditional learning
- Women faculty membership discrimination and bias identification and causing factors
- Gender Gap in Mathematical, Computing, and Natural Sciences

Challenges and Potential Collaborations

- Advancing training of women chemists, their research needs and technology transfer abilities
- Creation of equal opportunities for women so they can choose what they want to do, in a gender-bias free family; societal and educational environment
- Quotas granting to females in colleges in STEM.
- Organization of summer camps for young school students involving attractive STEM courses
- Equitable funding resources allocation to men and women

Chemical, Biological, and Nuclear Security

Objectives

- Organisation for the Prohibition of Chemical Weapons (OPCW) Knowledge, Ethics and Responsibility
- Ethical aspects and responsibility of the decision-makers.

Highlights of the Workshop

- Chemical and Biological Weapons Convention and Challenges
- Significance, relevance, and responsibilities of chemical science on the prohibition of chemical weapons on a regional and a global scale
- Theoretical knowledge and practical chemistry knowledge for screening and identifying chemical warfare agents
- Degradation of toxic chemicals and biological products and procedures to control and coordinating emergency response
- Health effects of exposure to chemical weapons

Challenges and Potential Collaborations

- Peaceful uses of chemistry, emphasizing international cooperation and capacity-building
- The global endeavor to permanently eliminate

chemical weapons,

- New threats and risks and protective measures against these weapons

Science and Technology Education at All Levels

Objectives

- Technical and scientific research, technology and education required for the development of human resources and institutional capacities
- To promote education for dissemination of knowledge wealth among the social groups within MENA region.

Highlights of the Workshop

- The Palestinian-German Science Bridge: Connecting people and knowledge. A pilot project to create a nucleus for the development of national science & technology infrastructure in Palestine.
- COVID-19 pandemic impact on dental education at Alexandria University, combining virtual simulation followed by physical lab activities
- COVID 19 Pandemic - E-and Media-learning of chemistry. The pros and cons of the sudden implementation of the online teaching and learning chemistry, at all levels.
- Natural science courses for freshman at Sabana University, Turkey. Structuring learning tools, considering size of the class, student heterogeneity for a seamless integration of teaching.

Challenges and Potential Collaborations

- Changing the dynamic culture of young children in terms of gender equity and inclusivity.
- Borderless collaboration, to exchange experiences and problem-solving
- Critical thinking and creativity rather than the traditional memorizing learning.
- Organization summer camps for young school students (male and female)
- Today's students as tomorrow's scientists and leaders need to learn chemistry and its links to climate change and UN SDGs.

Side Events

Entrepreneurship

Driven by the coronavirus, the climate crisis, the regional economic crisis, on the one hand, and the windows opened by the Abraham accords (normalization agreements between Israel, the United Arab Emirates, Bahrain and Morocco) and the Cypriot-lead regional

climate action plan, on the other, the participants were coached to work together on opportunities and challenges ahead; to discuss how science can contribute to opening new paths for business innovation and policy making. Groups of 5 - 7 participants were formed to discuss challenges derived from the presented research works, emphasizing:

- the effectiveness of current and proposed research to build a sustainable future
- the importance of knowledge in managing the future of the region's economies and societies.
- connecting people through opportunities that are economically worth their while
- identifying collaborators to initiate interdisciplinary research, raising funds and capturing the interest of entrepreneurs and policymakers for support

Early Career Program (ECP)

Networking, mentoring and learning opportunities were provided by the ECP for professionals aged 35 and younger, supporting career advancement through communication and exchange of ideas among them; to learn and to actively connect the leaders of tomorrow and the emerging chemistry professionals with established professionals; to transform their careers through the sharing of knowledge, contacts and experiences. Over the years, the ECP has become well organized and as such has a positive impact in integrating young professionals into the global chemistry community. Hundreds of early career professionals have passed through the MCF events and activities.

COP27 Climate Change Conference

In parallel to Malta X, the UN Climate Change Conference 2022 in Sharm El-Sheik, Egypt, hosted policymakers, environmental activists and business executives, including several long-time Malta participants, to discuss urgently needed action on the climate crisis, in regard to poverty, infectious disease, forced migration, and conflict.. The primary focus was to reduce emissions so that global temperature rises are kept to below 1.5 °C, a harm that is already severe and critical in the vulnerable MENA region. A commitment was made to create a "loss and damage" fund to help the global south recover from the devastating effects of increasingly extreme weather events, reducing their greenhouse gas emissions.

IUPAC Water in the Middle East Conference

IUPAC through ChemRAWN Committee intends to hold a conference on water scarcity and water

problems and solutions in MENA. A preliminary session was held in which Malta X participants discussed and suggested objectives and topics to be addressed in the conference, including:

- To develop a holistic approach to deal with the energy-water-climate nexus in MENA region
- To form a regional framework for continuous information exchange on climate change impacts and adaptation
- The impacts of climate change on water resources and the associated vulnerability and integration into sustainable development planning
- Best techniques and practices adjusted to drought and flood management and the environment
- Management of food production, rangelands, soil, water and eco-systems conservation.
- Digital and AI technology
- Knowledge gaps, opportunities and recommendations for researchers and policy makers on short and long-term vulnerability to climate change and water resource scarcity.

Concluding Remarks

The success of the Malta Conference series proves that the original idea and intention behind this initiative is becoming a reality. Scientists, decision-makers and representatives of civil society use the MCF platform for conducting fruitful dialogue on burning issues affecting the scientific community and MENA society. The growing interest in MCF shows that there is a growing consensus that the Malta Conferences has become the leading event of regional science diplomacy. It was generally agreed that the Malta X conference with its impressive participation, and a comprehensive program was a complete success. The conference ended with the conviction that professionals can be agents of change through co-operative innovation, and collaboration. The participants were enthusiastic to begin the work of building on all that was shared and achieved.

Acknowledgments

The organizers of the Malta X anniversary conference acknowledge the financial support by a large number of supporters and are especially grateful for the support endowed by the Alfred Bader Foundation, American Chemical Society, kENUP Foundation, Alexander von Humboldt Foundation, Organization for the Prohibition of Chemical Weapons, French Embassy in Malta, Malta Government and IUPAC.

The Future of Chemistry: Catalyzing Innovation for Sustainable Development.

The 2023 **World Chemistry Leadership Meeting** (WCLM) of IUPAC will be held during the World Chemistry Congress (WCC) at The Hague in The Netherlands on 23 August 2023. The theme of the meeting has its roots in a relatively new (2019) IUPAC project—the identification of the Top Ten Emerging Technologies in Chemistry—technologies that are judged to have the highest potential to improve the quality of life, contribute to economic growth, and advance society towards a more sustainable future. Every year and since 2019 when this project was initiated as one marking IUPAC's 100th anniversary, it has sparked a global conversation about how chemistry is evolving, and it has raised questions such as what is the “next best thing” in chemistry? how do we prepare for it? where is chemistry heading with regards to access to resources, regulation, energy, health, materials, *etc.*?

While this year's Top Ten emerging Technologies will be revealed in a later issue of *Chemistry International*, the 2023 WCLM will attempt to answer some of the aforementioned questions. In planning for this biennial meeting, the WCLM organizers reached out to leaders in the global chemical community and asked what they perceived as Society's most pressing problems and what challenges chemistry faces in finding solutions to those problems. The time allotted to the WCLM will not permit us to provide a comprehensive overview, but we do hope that the topics selected will be of interest to researchers from all areas of chemistry, including industry, government, and academia.

The following topics were selected:

- The digitalization of chemistry (artificial intelligence, machine learning, virtual reality, quantum computers, robotics)
- The advanced chemical recycling of plastics
- New fuels (the future of energy and the environment)
- Pandemic responsiveness (speed of testing, personalized medicine, wearable sensors)
- New methods for drug discovery (programmable chemical syntheses, spatial genomics—will build on the first bullet point above)
- The future of chemistry education (how should chemists be prepared for the lab of the future, for data sharing/management, for the interdisciplinary nature of scientific research, *etc.*?)



We are inviting one speaker per topic for a fifteen to twenty minute presentation. Time will be allotted at the end for a wrap-up and a question-and-answer session. Pending speaker permissions, we will record the session and post it to the IUPAC YouTube channel.

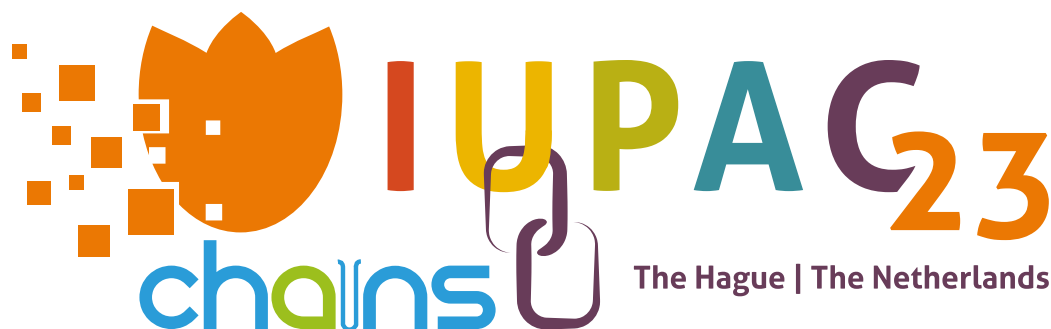
The goal with this WCLM is to lay a foundation for future meetings where chemistry leaders from around the world will gather, learn more about emerging trends in chemistry, and determine what they need to do to prepare their labs, their researchers, and the next generation of students for a successful future.

Look for progress on the development of the 2023 WCLM in future editions of *Chemistry International* as well as in future editions of IUPAC Concentrates. We look forward to seeing you in The Hague and invite your feedback in order to shape future meetings that will meet your needs and expectations.

The 2023 WCLM Organizing Team

Michael Droescher; Jeremy Frey; Zhigang Shuai; Bonnie Lawlor; Fabienne Meyers; Greta Heydenrych

<https://iupac.org/tag/wclm/>



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